DRAFT FINAL

PHASE I RFI/RI WORK PLAN

PRESENT LANDFILL (SWMU 114)
AND INACTIVE HAZARDOUS WASTE
STORAGE AREA (SWMU 203)
OPERABLE UNIT NO. 3
ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

ENVIRONMENTAL RESTORATION PROGRAM

JUNE 4, 1990

VOLUME II - APPENDIXES

APPENDIX B
DESIGN DRAWINGS FOR 1974 AND 1982 REMEDIAL CONSTRUCTION

(Copies of previously reduced reproductions of plans - may not be to scale.)

APPENDIX C
REAL TIME SOIL GAS SURVEY, SEPTEMBER 1987

Chen & Associates
Consulting Geotechnical Engineers

96 South Zuni
Denver, Colorado 80223
303/744-7105

Casper
Colorado Springs
Ft. Collins
Glenwood Springs
Phoenix
Rock Springs
Salt Lake City
San Antonio

September 10, 1987

Subject: Real Time Soil-Gas, Rocky Flats Landfill, Rocky Flats Plant, Golden, Colorado

Job No. 6 011 87

Rockwell International
Rocky Flats Plant
North American Space Operations
P.O. Box 464
Golden, Colorado 80402-0464

Attention: Mr. Tom Greengard

As requested, Chen & Associates conducted a real time soil-gas survey at the Rocky Flats landfill on September 1 and 2, 1987. Twenty points were measured in the landfill for methane and hydrogen sulfide. The location of those points are shown on Figure 1.

Methane was analyzed by a Century OVA 128 flame ionization detector in the gas chromatography mode. Hydrogen sulfide was analyzed by a Photovac 10S50 gas chromatograph with a photoionization detector. The summary of the analyzed compounds are shown in Table I. All sample and QA/QC Photovac 10S50 chromatograms are shown in Attachment 1.

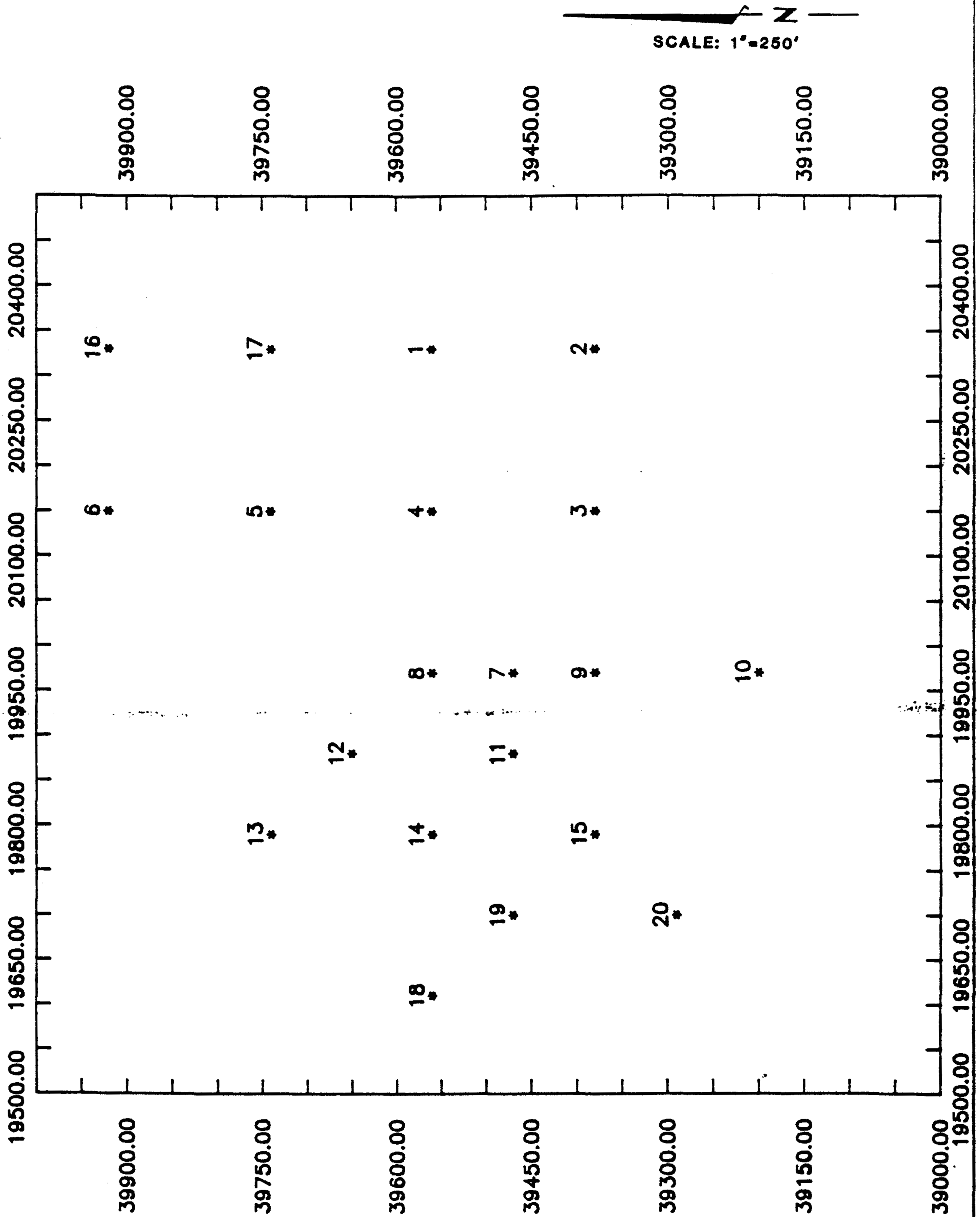
If you have any questions or if we may be of further service, please do not hesitate to contact us.

Sincerely,

CHEN & ASSOCIATES, INC.

By ______________________
David C. Constant

DCC/eac
Rev. By: DRG
Encs.



6 011 87	**Chen & Associates**	SOIL GAS SAMPLING POINTS	Fig. 1

TABLE I

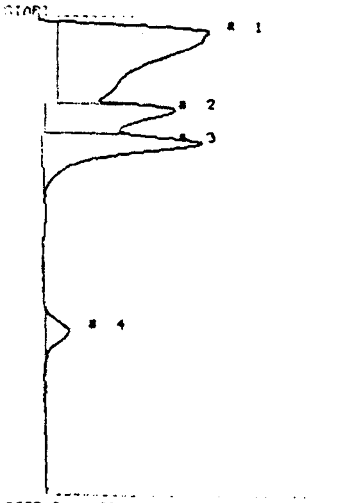
SUMMARY OF HYDROGEN SULFIDE AND METHANE RESULTS

Soil-Gas Sampling Point	Location	Hydrogen Sulfide Value (ppm)	Methane Value (ppm)
1	N39560 E20330	0	0
2	N39380 E20330	0	0.2
3	N39380 E20150	0	0
4	N39560 E20150	0	0
5	N39740 E20150	0	0.4
6	N39920 E20150	0	0
7	N39740 E19970	0	0
8	N39560 E19970	0	0
9	N39380 E19970	0	0
10	N39200 E19970	0	0
11	N39470 E19880	0	0
12	N39650 E19880	0	0
13	N39740 E19790	0	0
14	N39560 E19790	0	0

TABLE I (cont.)

SUMMARY OF HYDROGEN SULFIDE AND METHANE RESULTS

Soil-Gas Sampling Point	Location	Hydrogen Sulfide Value (ppm)	Methane Value (ppm)
15	N39380 E19790	0	0
16	N39920 E20330	0	0
17	N39740 E20330	0	0
18	N39560 E19610	0	0
19	N39470 E19700	0	0
20	N39290 E19700	0	0



STOP @ 60.0
SAMPLE RUN SEP 1 1987 10: 4
ANALYSIS # 27 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND NAME [illegible]

UNKNOWN [illegible]
[illegible] PPM
UNKNOWN 3 [illegible]
UNKNOWN [illegible]

PHOTOVAC

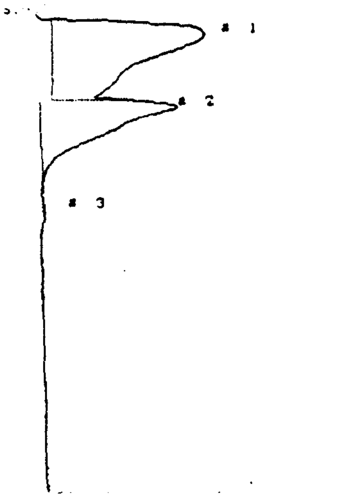
CALIBRATED PEAK 3,H2S

SAMPLE RUN SEP 1 1987 10: 5
ANALYSIS # 27 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND NAME [illegible]

UNKNOWN [illegible]
UNKNOWN [illegible]
[illegible] PPM
UNKNOWN [illegible]

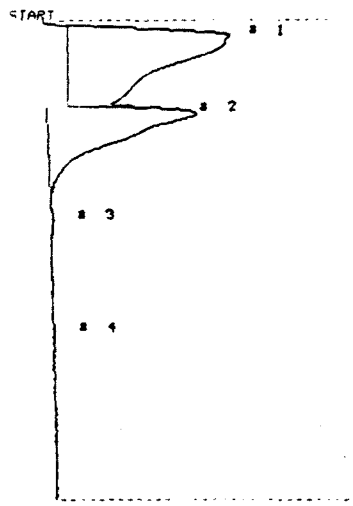
H_2S Calibration



STOP @ [illegible]
SAMPLE RUN SEP 1 1987 10: 7
ANALYSIS # 28 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND [illegible]

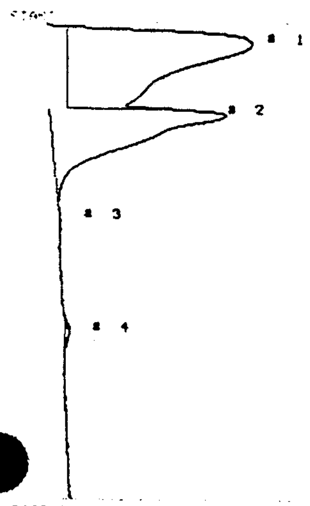
Air Check



STOP @ 60.0
SAMPLE RUN SEP 1 1987 10:10
ANALYSIS # 29 ROCKY FLATS
TEMPERATURE 23 KMM DCC
GAIN 100 601187

COMPOUND NAME [illegible]

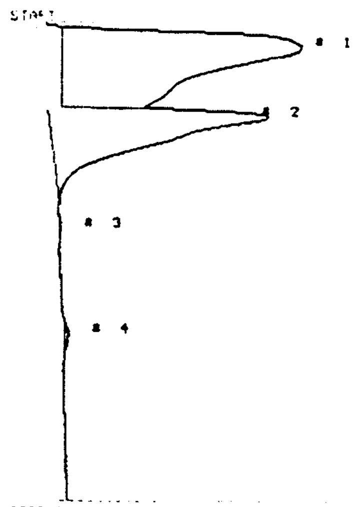
Sample Equipment Check



STOP @ 62.2
SAMPLE RUN SEP 1 1987 10:20
ANALYSIS # 31 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601:87

COMPOUND NAME

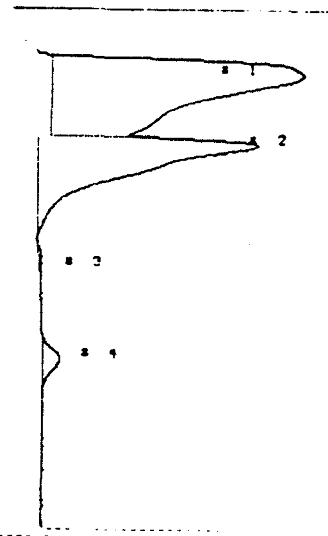
1



STOP @ 60.
SAMPLE RUN SEP 1 1987 10:23
ANALYSIS # 32 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601:87

COMPOUND NAME

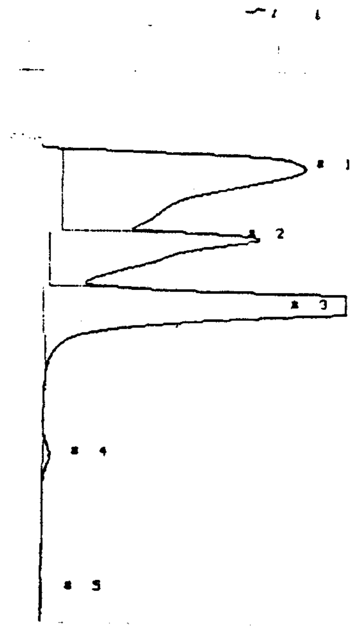
2



STOP @ 60.3
SAMPLE RUN SEP 1 1987 10:33
ANALYSIS # 33 ROCKY FLATS
TEMPERATURE 23 KMM DCC
GAIN 100 601:87

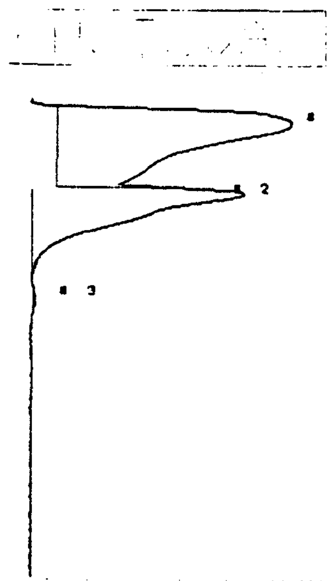
COMPOUND NA

3



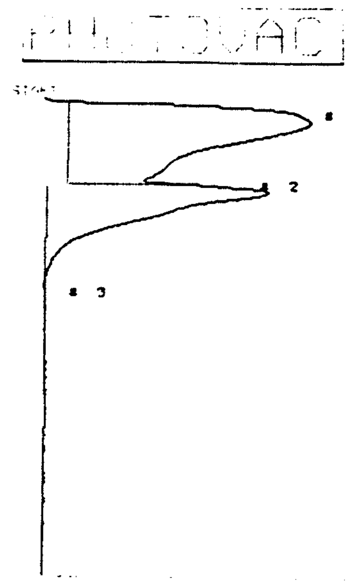
STOP @ 60.0
SAMPLE RUN SEP 1 1987 10:42
ANALYSIS # 36 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME



STOP @ 60.0
SAMPLE RUN SEP 1 1987 10:44
ANALYSIS # 37 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME



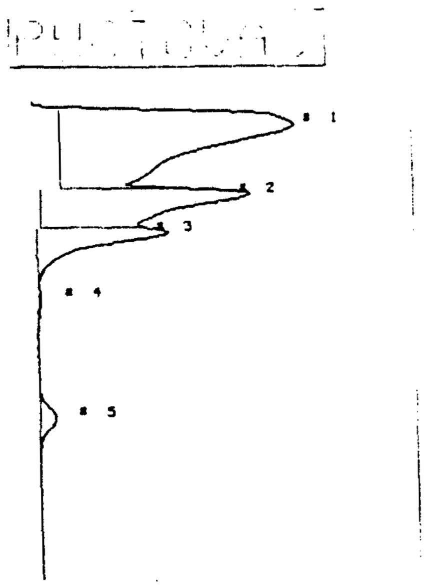
STOP @ 60.0
SAMPLE RUN SEP 1 1987 10:52
ANALYSIS # 38 ROCKY FLATS
TEMPERATURE 24 KMM OCC
GAIN 100 601187

COMPOUND NAME

Air Check

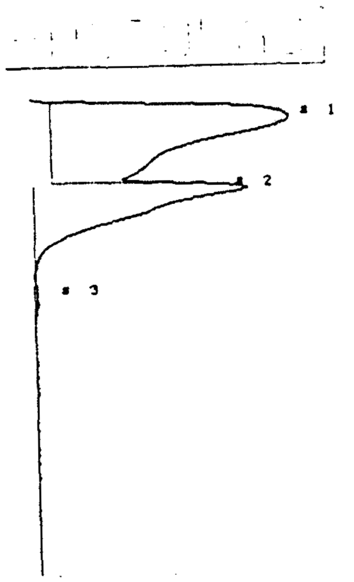
4

5



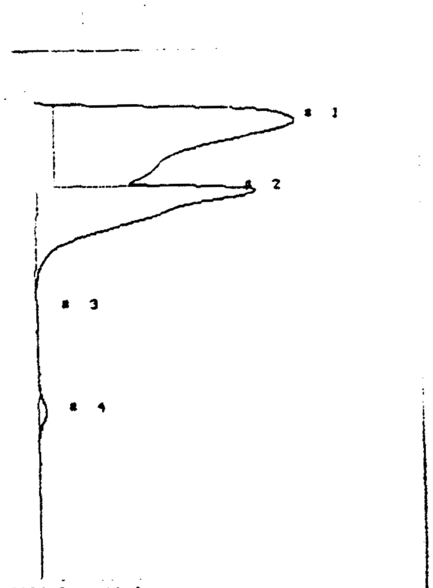
STOP @

SAMPLE RUN SEP 1 1987 10:54
ANALYSIS # 39 ROCKY FLATS
TEMPERATURE 25 KMM DCC
GAIN 100 601187



STOP @ 62.0

SAMPLE RUN SEP 1 1987 10:57
ANALYSIS # 40 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187



STOP @ 62.0

SAMPLE RUN SEP 1 1987 11: 4
ANALYSIS # 41 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

Air Check

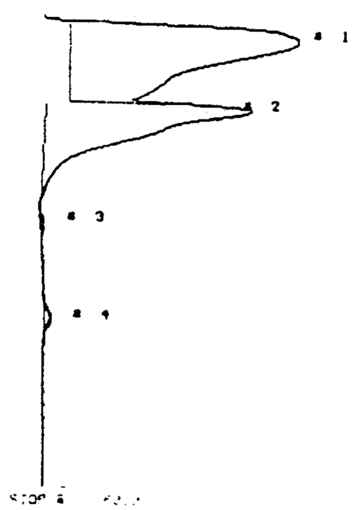
PHOTOVAC

CALIBRATED PEAK 3,H2S

SAMPLE RUN SEP 1 1987 10:55
ANALYSIS # 39 ROCKY FLATS
TEMPERATURE 24 KMM DCC
GAIN 100 601187

COMPOUND NAME

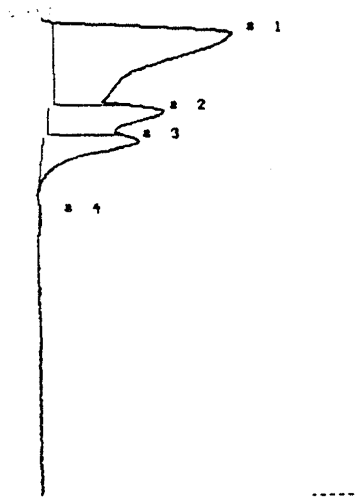
H_2S Calibration



SAMPLE RUN SEP 1 1987 11:14
ANALYSIS # 43 ROCKY FLATS
TEMPERATURE 25 KMM OCC
GAIN 100 601187

COMPOUND NAME

7



SAMPLE RUN SEP 2 1987 8:56
ANALYSIS # 6 ROCKY FLATS
TEMPERATURE 22 KMM OCC
GAIN 100 601187

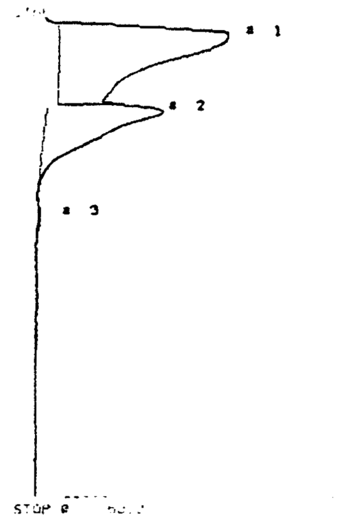
COMPOUND NAME PEAK AREA

CALIBRATED PEAK 3.H2S

SAMPLE RUN SEP 2 1987 8:56
ANALYSIS # 6 ROCKY FLATS
TEMPERATURE 21 KMM OCC
GAIN 100 601187

COMPOUND NAME

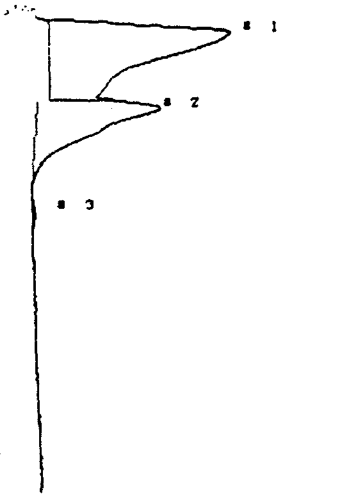
H_2S Calibration



SAMPLE RUN SEP 2 1987 8:52
ANALYSIS # 5 ROCKY FLATS
TEMPERATURE 21 KMM OCC
GAIN 100 601187

COMPOUND NAME

Air Check



IN 100 601187

COMPOUND NAME PEAK R.T. AREA/PPM

Sampling Equipment Check

START

STOP 0 60.0

SAMPLE RUN SEP 2 1987 10:44

ANALYSIS # 2 ROCKY FLATS

TEMPERATURE 27 KMM DCC

GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	4.5 US
UNKNOWN	2	12.0	2.4 US

Air Check

START

STOP 0 60.0

SAMPLE RUN SEP 2 1987 10:47

TEMPERATURE 28 ROCKY FLATS

GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	4.6 US
UNKNOWN	2	12.0	1.9 US
H2S	3	16.1	13.56 PPM
UNKNOWN	4	25.0	13.7 mUS

PHOTOVAC

CALIBRATED PEAK

SAMPLE RUN SEP 2 1987 10:48

ANALYSIS # 3 ROCKY FLATS

TEMPERATURE 28 KMM DCC

GAIN 100 601187

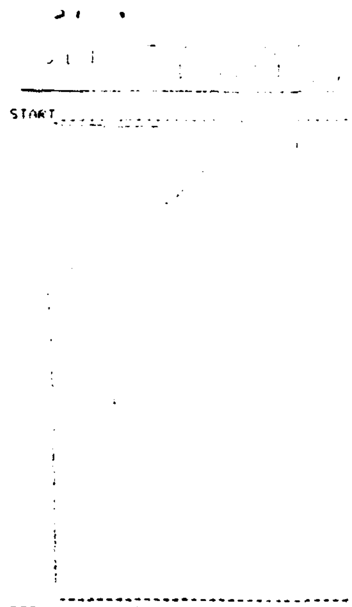
COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	4.6 US
UNKNOWN	2	12.0	1.9 US
H2S	3	16.1	9.999 PPM
UNKNOWN	4	25.0	13.7 mUS

STOP @ 60.0

SAMPLE RUN		SEP 2 1987	11: 0
ANALYSIS #	5	ROCKY FLATS	
TEMPERATURE	30	KMM DCC	
GAIN	100	601187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	5.5 US
[illegible]NOWN	2	12.0	3.0 US
[illegible]NOWN	3	25.8	16.0 mUS
[illegible]NOWN	4	35.7	142.4 mUS

8



STOP @ 60.0

SAMPLE RUN		SEP 2 1987	10:50
ANALYSIS #	4	ROCKY FLATS	
TEMPERATURE	30	KMM DCC	
GAIN	100	601187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	5.2 US
UNKNOWN	2	12.0	3.1 US
UNKNOWN	3	25.3	16.7 mUS
UNKNOWN	4	36.5	31.5 mUS

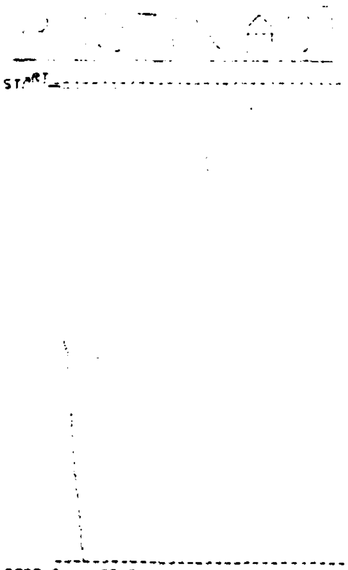
9

STOP @ 60.0

SAMPLE RUN		SEP 2 1987	11: 6
ANALYSIS #	6	ROCKY FLATS	
TEMPERATURE	32	KMM DCC	
GAIN	100	601187	

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	6.2 US
UNKNOWN	2	12.0	3.2 US
UNKNOWN	3	20.2	9.7 US
UNKNOWN	4	35.5	1.2 US

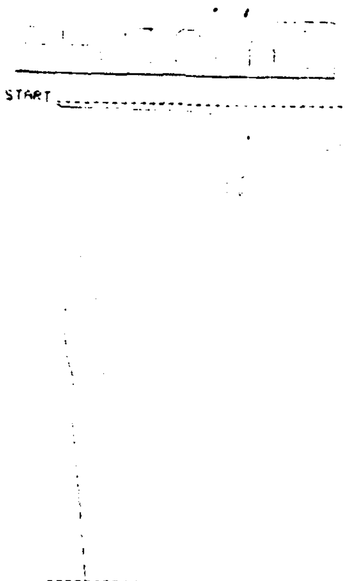
10



STOP 0 60.0
SAMPLE RUN SEP 2 1987 11:11
ANALYSIS # 8 ROCKY FLATS
TEMPERATURE 33 KMM OCC
GAIN 100 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.1	7.1 US
UNKNOWN	2	12.0	3.7 US
UNKNOWN	3	25.7	25.9 mUS
UNKNOWN	4	35.2	14.1 mUS

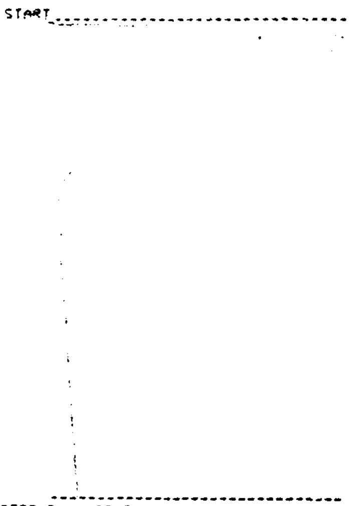
11



STOP 0 60.0
SAMPLE RUN SEP 2 1987 11:17
ANALYSIS # 9 ROCKY FLATS
TEMPERATURE 35 KMM OCC
GAIN 100 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	10.7 US
UNKNOWN	2	11.8	4.5 US
UNKNOWN	3	25.5	15.1 mUS
UNKNOWN	4	34.9	10.2 mUS

12



STOP 0 60.0
SAMPLE RUN SEP 2 1987 11: 9
ANALYSIS # 7 ROCKY FLATS
TEMPERATURE 32 KMM OCC
GAIN 100 091187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	2.9	6.3 US
UNKNOWN	2	12.0	3.4 US
UNKNOWN	3	25.3	15.1 mUS

Air Check

START

STOP @ 60.0

SAMPLE RUN SEP 2 1987 11:22

ANALYSIS # 10 ROCKY FLATS

TEMPERATURE 37 KMM DCC

GAIN 100 001187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.4	13.1 US
UNKNOWN	2	11.9	5.0 US
UNKNOWN	3	25.4	38.3 mUS
UNKNOWN	4	33.6	59.9 mUS

13

START

STOP @ 60.0

SAMPLE RUN SEP 2 1987 11:43

ANALYSIS # 18 ROCKY FLATS

TEMPERATURE 37 KMM DCC

GAIN 100 001187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	8.8	2.0 US
UNKNOWN	3	12.1	1.3 US
UNKNOWN	4	14.4	2.0 US
UNKNOWN	5	25.7	30.3 mUS
UNKNOWN	6	34.4	65.1 mUS

14

PHOTOVAC

START

STOP @ 60.0

SAMPLE RUN SEP 2 1987 11:37

ANALYSIS # 17 ROCKY FLATS

TEMPERATURE 38 KMM DCC

GAIN 100 001187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	2	8.6	2.0 US
UNKNOWN	3	12.0	1.3 US
H2S	4	14.4	11.41 PPM
H2S	5	16.6	14.31 PPM
UNKNOWN	6	25.1	20.7 mUS
UNKNOWN	7	34.3	45.7 mUS

PHOTOVAC

CALIBRATION

SAMPLE RUN SEP 2 1987 10:38

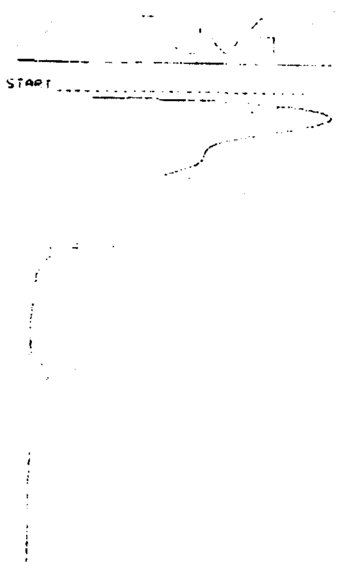
ANALYSIS # 17 ROCKY FLATS

TEMPERATURE 37 KMM DCC

GAIN 100 001187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.5	4.4 US
UNKNOWN	2	8.6	2.0 US
UNKNOWN	3	12.0	1.3 US
UNKNOWN	4	14.4	1.2 US
H2S	5	16.6	10.00 PPM
UNKNOWN	6	25.1	20.7 mUS
UNKNOWN	7	34.3	45.7 mUS

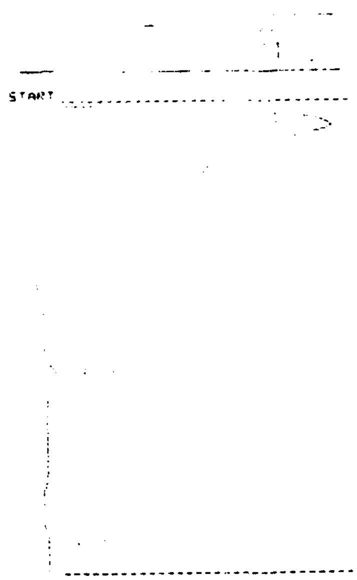
Air Check



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:11
ANALYSIS # 21 ROCKY FLATS
TEMPERATURE 35 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	6.1 US
UNKNOWN	2	12.0	3.4 US
UNKNOWN	3	20.6	75.5 mUS
UNKNOWN	4	35.9	176.6 mUS

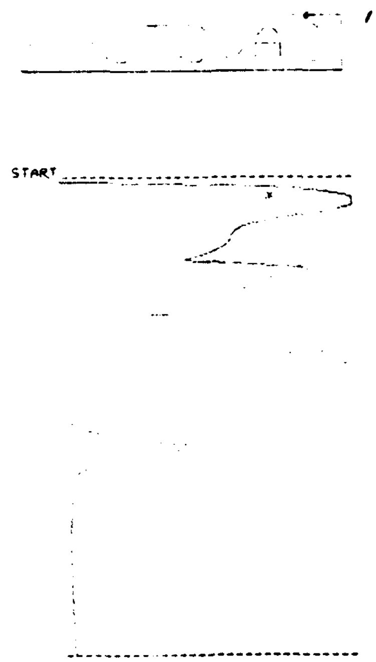
15



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:19
ANALYSIS # 22 ROCKY FLATS
TEMPERATURE 36 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.3	6.0 US
UNKNOWN	2	12.1	3.7 US
UNKNOWN	3	26.4	30.1 mUS
UNKNOWN	4	35.0	33.3 mUS
UNKNOWN	5	57.3	17.1 mUS

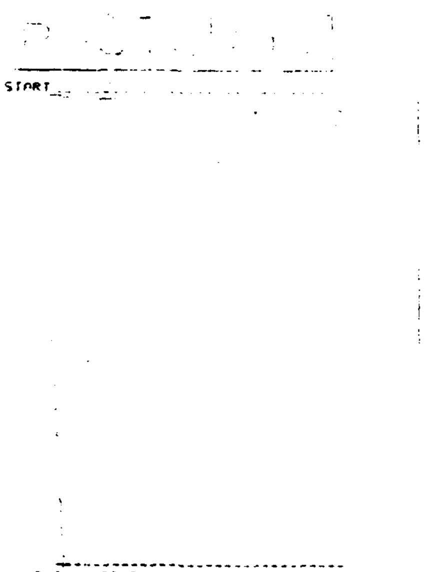
16



STOP @ 60.0
SAMPLE RUN SEP 2 1987 12:26
ANALYSIS # 23 ROCKY FLATS
TEMPERATURE 37 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.4 US
UNKNOWN	2	12.1	3.5 US
UNKNOWN	3	20.5	11.6 US
UNKNOWN	4	34.4	976.2 mUS

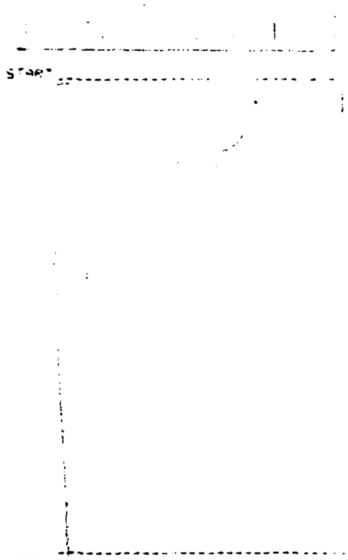
17



STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:28
ANALYSIS # 24 ROCKY FLATS
TEMPERATURE 38 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.6 VS
UNKNOWN	2	12.0	3.2 VS
[illegible]2S	3	16.8	7.253 PPM
[illegible]KNOWN	4	25..	6.5 mVS
[illegible]KNOWN	5	34.6	36.6 mVS



STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:31
ANALYSIS # 25 ROCKY FLATS
TEMPERATURE 39 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	2.9	2.1 VS
UNKNOWN	2	12.0	3.8 VS
UNKNOWN	3	25.6	18.2 mVS

STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:35
ANALYSIS # 26 ROCKY FLATS
TEMPERATURE 40 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	8.4 VS
UNKNOWN	2	12.0	3.8 VS
UNKNOWN	3	20.3	9.1 VS
UNKNOWN	4	33.7	300.3 mVS

PHOTOVAC

CAL.[illegible]

SAMPLE RUN SEP 2 1987 12:29
ANALYSIS # 24 ROCKY FLATS
TEMPERATURE 38 KMM DCC
GAIN 100 601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	6.6 VS
UNKNOWN	2	12.0	3.2 VS
H2S	3	16.8	3.334 PPM
UNKNOWN	5	34.6	38.6 mVS

Air Check

H_2S Calibration

START

STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:40

ANALYSIS #	28	ROCKY FLATS
TEMPERATURE	41	KMM DCC
GAIN	100	601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.1	3.4 US
UNKNOWN	2	12.0	3.4 US
H2S	3	16.6	10.00 PPM
UNKNOWN	4	25.4	84.8 mUS
UNKNOWN	5	34.0	16.2 mUS
UNKNOWN	6	57.3	28.8 mUS

PHOTOVAC

SAMPLE RUN SEP 2 1987 12:43

ANALYSIS # 28 ROCKY FLATS

TEMPERATURE	41	KMM DCC
GAIN	100	601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.1	3.5 US
UNKNOWN	2	12.0	3.4 US
H2S	3	16.6	10.00 PPM
UNKNOWN	4	25.4	84.8 mUS
UNKNOWN	5	34.0	16.2 mUS
UNKNOWN	6	57.3	28.8 mUS

START

STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:38

ANALYSIS #	27	ROCKY FLATS
TEMPERATURE	41	KMM DCC
GAIN	100	601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.0	3.3 US
UNKNOWN	2	12.0	4.2 US
UNKNOWN	3	25.6	42.7 mUS
UNKNOWN	4	34.0	25.8 mUS

19

START

56-8

STOP @ 60.0

SAMPLE RUN SEP 2 1987 12:46

ANALYSIS #	29	ROCKY FLATS
TEMPERATURE	41	KMM DCC
GAIN	100	601187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.2	3.5 US
UNKNOWN	2	11.7	4.6 US
UNKNOWN	3	25.3	30.0 mUS
UNKNOWN	4	33.1	89.2 mUS

20

H_2S Calibration

Pump
~~Air~~ Check

STOP 0 60.0

SAMPLE RUN SEP 2 1987 12:40
ANALYSIS # 30 ROCKY FLATS
TEMPERATURE 41 KMM OCC
GAIN 1 00 001187

COMPOUND NAME	PEAK	R.T.	AREA/PPM
UNKNOWN	1	3.1	10.6 US
UNKNOWN	2	11.9	4.3 US
UNKNOWN	3	25.5	34.7 mUS
UNKNOWN	4	33.2	6.6 mUS

Pump Check

APPENDIX D
SELECTED EXCERPTS, DRAFT BACKGROUND GEOCHEMICAL CHARACTERIZATION REPORT

DRAFT BACKGROUND GEOCHEMICAL CHARACTERIZATION REPORT

ROCKY FLATS PLANT
GOLDEN, COLORADO

Prepared for:

Rockwell Internatinal
Aerospace Operations
Rocky Flats Plant
Golden, Colorado 80401

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DECEMBER 15, 1989

BACKGROUND GEOCHEMICAL CHARACTERIZATION REPORT

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SECTION 1.0

EXECUTIVE SUMMARY AND RECOMMENDATIONS

The background characterization program is designed to document the spatial and temporal variability of constituents in order to facilitate the interpretation of chemical results in non-background areas. This document summarizes the background data for ground water, surface water, sediments, and borehole materials, and identifies preliminary statistical boundaries of background variability. Spatial variations in the chemistry of borehole materials and water have been addressed by placing sample locations throughout the background areas at the Plant; however, the goal of evaluating temporal variations in water chemistry cannot be achieved until at least two years of quarterly data have been collected. This preliminary report will be finalized in the near future by incorporation of analytical data currently unavailable for samples collected to date, which includes a second round of ground-water samples for which no data is available at this time. Other additions to the final report are noted in the recommendations at the end of this section.

The boundary of background variability has been quantified in this report through the calculation of tolerance intervals assuming a normal distribution. The upper limit of the tolerance interval or the maximum detected value for each parameter in ground-water, surface water, sediment and borehole samples are provided in Tables 1-1 through 1-4, respectively. Maximum detected values are provided where there is insufficient data to calculate tolerance intervals. This condition results from there being an insufficient number of samples, or where there is an insufficient number of detectable concentrations for a given analyte. Alternative statistical methods are identified, such as ANOVA or test of proportionality, to determine whether non-background data significantly differs from the background population where tolerance intervals have not been calculated.

As depicted in Table 1-1, high sodium, sulfate, and total dissolved solids distinguishes the unweathered (deep) sandstone ground water from the other shallow ground-water

TABLE 1-1

BACKGROUND GROUND WATER (ROUND 1)
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Dissolved Metals							
Aluminum	mg/l	ND	ND	ND	ND	ND	0.327*
Antimony	mg/l	ND	ND	ND	ND	ND	ND
Arsenic	mg/l	ND	ND	ND	ND	ND	0.0186*
Barium	mg/l	ND	ND	ND	ND	ND	ND
Beryllium	mg/l	ND	ND	ND	ND	ND	ND
Cadmium	mg/l	ND	ND	ND	ND	ND	ND
Calcium	mg/l	85	76.8*	138	73.4*	65.7*	64.6
Cesium	mg/l	ND	ND	ND	ND	ND	ND
Chromium	mg/l	ND	ND	ND	ND	0.0122*	ND
Cobalt	mg/l	ND	ND	ND	ND	ND	ND
Copper	mg/l	ND	ND	ND	ND	ND	ND
Iron	mg/l	0.266*	ND	0.94*	ND	ND	ND
Lead	mg/l	ND	ND	ND	ND	ND	ND
Lithium	mg/l	ND	0.172*	0.028	.031*	0.0106*	ND
Magnesium	mg/l	5.79*	15.3*	26.57	45.3*	9.41*	ND
Manganese	mg/l	0.365	0.088*	0.686*	0.126*	0.292*	0.0182*
Mercury	mg/l	ND	ND	0.003*	.008*	ND	ND
Molybdenum	mg/l	0.0136*	ND	ND	0.015*	0.015*	0.112*
Nickel	mg/l	0.0432*	ND	ND	ND	ND	ND
Potassium	mg/l	7.73*	ND	ND	ND	ND	21.89*
Selenium	mg/l	ND	ND	0.0114*	ND	ND	0.041*
Silver	mg/l	ND	ND	ND	ND	ND	ND
Sodium	mg/l	13.4	98.7*	88	36.9*	25.6*	599
Strontium	mg/l	0.159*	ND	ND	ND	ND	0.451*
Thallium	mg/l	ND	ND	ND	0.01*	ND	ND
Tin	mg/l	ND	ND	ND	ND	ND	
Vanadium	mg/l	ND	ND	ND	ND	ND	ND
Zinc	mg/l	0.141*	ND	0.0212*	0.107*	ND	0.564

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TABLE 1-1 (cont.)

BACKGROUND GROUND WATER (ROUND 1)
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Other							
Total Dissolved Solids	mg/l	352	520*	947	320*	170*	1761
Carbonate	mg/l	ND	ND	ND	ND	ND	49
Bicarbonate	mg/l	436	470*	719	400*	140*	412
Chloride	mg/l	15.6	20*	40.29	11*	15*	607
Sulfate	mg/l	45.1	86*	150	44*	16*	950
Nitrate	mg/l	2.98	0.18*	0.69*	0.58*	1.6*	0.610
Cyanide	mg/l	.0038*	ND	ND	0.0036*	ND	ND
pH	----	8.6 (5.98)	7.4* (7.1)**	8.68 (6.12)	8.2* (7.4)**	7.5* (7.2)**	10.57 (7.43)
Dissolved Radionuclides							
Gross Alpha	pCi/l	12.543	27±12*	13.515	12±4*	7±5*	13±5*
Gross Beta	pCi/l	14.570	12±5*	18.530	7±2*	2±3*	15±4*
Uranium 233, 234	pCi/l	1.647	11±1*	6.481	5.8±0.6*	1.1±0.3*	12.936
Uranium 235	pCi/l	0.000	0.3±0.1*	0.232	0.2±0.1*	0±0.1*	0.135
Uranium 238	pCi/l	0.195	7.7±0.7*	5.084	3.2±0.5	0.6±0.2*	3.3507
Strontium 89, 90	pCi/l	0.552	0.1±0.4*	0.878	0.1±0.5	-0.1±0.6*	0.2±5*
Plutonium 239, 240	pCi/l	0.009	0±0.01*	0.012	0.03±0.02	0.01±0.01*	0.000
Americium 241	pCi/l	0.000	0±0.01*	0.012	0±0.01	0.01±0.01*	0.019
Cesium 137	pCi/l	0.603	0.2±0.6*	0.776	0.4±0.6	0.3±0.7*	0.7±0.5*
Tritium	pCi/l	309.149	100±150*	505.111	100±160	100±210*	731.876

* - Maximum Detected Value
** - Minimum Detected Value
ND - Not Detected
() - Tolerance Internal Lower Limit for Two-Sided Parameter

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TABLE 1-2

BACKGROUND SURFACE WATER (ROUNDS 1 and 2)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Round 1 (9 samples) Total	Round 1 (9 samples) Dissolved	Round 2 (7 samples) Total	Round 2 (7 samples) Dissolved
Metals					
Aluminum	mg/l	64.10*	0.485*	8.444	0.454*
Antimony	mg/l	ND	ND	ND	ND
Arsenic	mg/l	0.116*	ND	ND	ND
Barium	mg/l	4.49*	ND	0.294*	ND
Beryllium	mg/l	0.0097*	ND	ND	ND
Cadmium	mg/l	0.0690*	ND	ND	ND
Calcium	mg/l	254.11	99.14	105.03	93.27
Cesium	mg/l	2.53*	ND	ND	ND
Chromium	mg/l	0.0598*	ND	0.0115*	ND
Cobalt	mg/l	0.0730*	ND	ND	ND
Copper	mg/l	0.180*	ND	ND	ND
Iron	mg/l	692.59	4.69*	12.070	0.453*
Lead	mg/l	0.233*	0.0055*	0.0308*	0.0131*
Lithium	mg/l	ND	ND	0.0192*	0.0166*
Magnesium	mg/l	27.71	11.98	17.578	15.74
Manganese	mg/l	1.140	0.826	1.101	0.232
Mercury	mg/l	0.001	0.002	0.004*	0.0004*
Molybdenum	mg/l	0.199*	ND	0.026	0.032
Nickel	mg/l	0.251*	ND	ND	ND
Potassium	mg/l	9.86*	ND	ND	ND
Selenium	mg/l	ND	ND	ND	ND
Silver	mg/l	0.148*	0.0125*	ND	ND
Sodium	mg/l	43.020	44.81	42.651	43.22
Strontium	mg/l	1.341	0.35	ND	ND
Thallium	mg/l	ND	ND	ND	ND
Tin	mg/l	0.969*	ND	ND	ND
Vanadium	mg/l	0.364*	ND	ND	ND
Zinc	mg/l	0.723*	.032	0.0892*	0.0228*

TABLE 1-2 (cont.)

BACKGROUND SURFACE WATER (ROUNDS 1 and 2)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Round 1 (9 samples) Total	Round 1 (9 samples) Dissolved	Round 2 (7 samples) Total	Round 2 (7 samples) Dissolved
Other					
Total Dissolved Solids	mg/l	329.52	NA	365.15	NA
Carbonate	mg/l	ND	NA	ND	NA
Bicarbonate	mg/l	389.72	NA	344.21	NA
Chloride	mg/l	89.11	NA	82.56	NA
Sulfate	mg/l	50.20	NA	65.30	NA
Nitrate	mg/l	2.45	NA	2.1*	NA
Cyanide	mg/l	ND	NA	0.0043*	NA
pH	----	9.02 (5.89)	NA	8.3 (6.44)	NA
Radionuclides					
Gross Alpha	pCi/l	266.658	5.805	106.207	NA
Gross Beta	pCi/l	213.432	9.335	79.549	NA
Uranium 233, 234	pCi/l	1.250	3.684	1.326	NA
Uranium 235	pCi/l	0.106	0.364	0.000	NA
Uranium 238	pCi/l	0.937	2.311	0.977	NA
Strontium 89, 90	pCi/l	2.160	1.452	1.243	NA
Plutonium 239, 240	pCi/l	1.066	0.017	0.112	NA
Americium 241	pCi/l	0.111	0.014	0.014	NA
Cesium 137	pCi/l	12.788	0.591	1.059	NA
Tritium	pCi/l	266.107	NA	863.276	NA

NA - Not Analyzed
ND - Not Detected
* - Maximum Detected Value
() - Tolerance Interval Lower Limit for Two-Sided Parameter

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TABLE 1-3

BACKGROUND SEDIMENT
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Upper Limit (9 Samples)
Total Metals		
Aluminum	mg/l	24789
Antimony	mg/l	ND
Arsenic	mg/l	13.0*
Barium	mg/l	182*
Beryllium	mg/l	ND
Cadmium	mg/l	ND
Calcium	mg/l	72551
Cesium	mg/l	ND
Chromium	mg/l	43.38
Cobalt	mg/l	ND
Copper	mg/l	22.0*
Iron	mg/l	28308
Lead	mg/l	39.502
Lithium	mg/l	ND
Magnesium	mg/l	4110*
Manganese	mg/l	372.20
Mercury	mg/l	ND
Molybdenum	mg/l	ND
Nickel	mg/l	29.9*
Potassium	mg/l	ND
Selenium	mg/l	ND
Silver	mg/l	6.8*
Sodium	mg/l	ND
Strontium	mg/l	175*
Thallium	mg/l	ND
Tin	mg/l	ND
Vanadium	mg/l	50.2*
Zinc	mg/l	92.688

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TABLE 1-3 (cont.)

BACKGROUND SEDIMENT
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Upper Limit (9 Samples)
Other		
Nitrate	mg/l	ND
pH	----	9.03 (8.77)
Total Radionuclides		
Gross Alpha	pCi/l	60.137
Gross Beta	pCi/l	50.168
Uranium 233, 234	pCi/l	1.669
Uranium 235	pCi/l	0.176
Uranium 238	pCi/l	1.755
Strontium 89, 90	pCi/l	1.390
Plutonium 239, 240	pCi/l	0.096
Americium 241	pCi/l	0.029
Cesium 137	pCi/l	1.578
Tritium	pCi/l	0.408

ND - Not Detected
* - Maximum Detected Value
() - Tolerance Interval Lower Limit for Two-Sided Parameter

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TABLE 1-4

BACKGROUND BOREHOLE
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
Total Metals					
Aluminum	mg/l	25312	21663	13495	10300*
Antimony	mg/l	ND	ND	16.2*	ND
Arsenic	mg/l	15.86	7.7	15.05	3.6*
Barium	mg/l	155.8	345.8	240.1	165*
Beryllium	mg/l	11.27	17.75	11.8	2.2*
Cadmium	mg/l	3.2*	1.8*	ND	ND
Calcium	mg/l	43079	20811	10183	5940*
Cesium	mg/l	ND	274*	ND	ND
Chromium	mg/l	37.9	26.8	16.57	10.7*
Cobalt	mg/l	18.2*	15.9*	29.7*	20.5*
Copper	mg/l	20.03	26.7	30.62	19.6*
Iron	mg/l	22916	29991	41295	12300*
Lead	mg/l	18.04	26.4	34.5	13.4*
Lithium	mg/l	44.4	32.1	33.37	7.0*
Magnesium	mg/l	4425	6151	4896	2520*
Manganese	mg/l	422.9	545.1	656	305*
Mercury	mg/l	0.58*	0.44*	0.35*	0.27*
Molybdenum	mg/l	38.65	32.78	33.68	11.2*
Nickel	mg/l	43.27	35.4	56.95	14.3*
Potassium	mg/l	3336	2789	1400*	ND
Selenium	mg/l	ND	ND	ND	ND
Silver	mg/l	40.9*	33.5*	18.7*	12.7*
Sodium	mg/l	ND	3680*	ND	ND
Strontium	mg/l	226*	111.1	144.42	69.2*
Thallium	mg/l	ND	ND	ND	ND
Tin	mg/l	338*	441*	274*	268*
Vanadium	mg/l	54.67	58.2	47.7	22.2*
Zinc	mg/l	52.64	98.1	106.7	79.9*

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TABLE 1-4 (cont.)

BACKGROUND BOREHOLE
TOLERANCE INTERVAL UPPER LIMITS
MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
Other					
Sulfide	mg/l	13*	5*	5*	2*
Nitrate	mg/l	4.3*	4.274	2.0*	1.9*
pH	----	9.64 (6.06)	9.48 (6.96)	10.14 (7.04)	9.2* (8.0)**
Total Radionuclides					
Gross Alpha	pCi/l	37.108	51.710	52.302	37±17
Gross Beta	pCi/l	36.886	35.135	35.743	29±6
Uranium 233, 234	pCi/l	1.491	1.759	1.985	0.8±0.3
Uranium 235	pCi/l	0.087	0.169	0.258	0.1±0.1
Uranium 238	pCi/l	1.353	1.675	1.643	1.0±0.2
Strontium 89, 90	pCi/l	0.768	0.776	0.786	0.4±0.6
Plutonium 239, 240	pCi/l	0.017	0.023	0.020	0.01±0.01
Americium 241	pCi/l	0.018	NR	NR	NR
Cesium 137	pCi/l	0.082	0.113	ND	0.0±0.1
Tritium	pCi/l	0.410	0.299	0.322	0.39±0.15

ND - Not Detected
NR - Data Not Received
* - Maximum Detected Value
** - Minimum Detected Value
() - Tolerance Interval Lower Limit for Two-Sided Parameter

rockwell\bkgdchem\table1-4.jbb

subgroups. The shallow ground water subgroups are similar in chemistry; however, closer inspection suggests that the ground water of the Rocky Flats Alluvium is less saline than any of the other shallow ground-water subgroups it recharges. This phenomenon is likely a result of the relatively greater evaporative losses in the colluvium and valley fill (less saturated thickness than the Rocky Flats Alluvium), and in the case of the weathered and unweathered bedrock, longer contact time with these materials (less permeable than the Rocky Flats Alluvium).

Differences in the analytical results from Round 1 and Round 2 surface water samples document the temporal variation in surface water chemistry (Table 1-2). These differences include variability in the suite of parameters with detected concentrations as well as the magnitude of the concentrations. As discussed in Section 4.2, surface water becomes relatively less concentrated in sodium chloride and more concentrated in calcium bicarbonate as it flows from west to east. Surface water chemistry changes from west to east across the background areas reflect the increased influence of ground water on surface water quality.

Relative to the Rocky Flats Alluvium, colluvium, and weathered sandstone and claystone, the sediments have fewer detected trace metals and lower concentrations of aluminum, iron, and calcium (Tables 1-3 and 1-4). Potassium was also not detected in the sediments but was detected elsewhere. The absence of detected potassium, together with the lower concentrations of aluminum and iron, suggest that there is less clay in the sediments relative to the other materials. This is further supported by the physical description of this material, i.e., the sediments tend to be more coarse. A smaller clay fraction may also explain the fewer detections of trace metals owing to the high adsorptive capacity of the clay fraction.

To detect releases from sites/units, station-specific data will be compared to the range of background concentrations (tolerance intervals), and in the case of surface water and ground water, also compared to the concentrations at the station or well over time.

Borehole sampling data will be compared to the background tolerance intervals for the corresponding borehole material. A constituent concentration at a site/unit that is greater than the upper limit of the one-sided 95% tolerance interval at the 95% confidence level will be considered to likely represent contamination.

Determination that a constituent concentration in ground water or surface water represents contamination will be based on 1) comparison of new data to the background tolerance interval; 2) trend testing; and/or 3) use of control charts for annual means. As previously stated, at least two years of water quality data will be needed to perform the temporal tests (trend testing and control charts).

In the process of reviewing the background data, questions arose concerning appropriate background populations. Specifically, does a single population characterize (1) ground water sampled in valley fill associated with Rock Creek and Woman Creek, (2) ground water within valley fill and colluvium, (3) ground water within weathered claystone and weathered sandstone, and (4) weathered claystone and weathered sandstone materials?

In the review of Round 1 and Round 2 water data, it became apparent that temporal variation in surface water and ground-water sampling is a function of at least two factors: (1) natural variations in water quality, and (2) changes in the number and spatial representation of background samples due to the availability of water at sampling sites.

Similar issues arose in the review of borehole samples: (1) analyte concentrations may be dependent upon depth from surface, and (2) higher concentrations of analytes tend to cluster within the same sample.

For these reasons it is recommended that for the final background geochemical characterization report:

- the statistical distribution of the data be investigated, and the appropriate distribution be used in subsequent statistical analysis;

- multi-variate analysis of variance be used to evaluate the appropriateness of present division of ground-water populations and thus the potential for combining data from these populations into fewer water groups; and

- principal component analysis be investigated as a method to identify factors which may influence the distribution and concentration of analytes within background samples.

2.0 INTRODUCTION

2.1 PURPOSE

Representative background analytical data are necessary for meaningful interpretations of RCRA facility investigations and CERCLA remedial investigation (soils, bedrock, surface water, and ground water) analytical results. Background data assist in the evaluation of environmental degradation by determining spatial and temporal variability of a naturally-occurring constituent. These characteristics can be compared statistically with data from a downgradient site to determine the likelihood that a particular concentration of chemicals represents a release from the SWMU.

This document presents the results of the first phase of a background hydrogeochemical characterization conducted pursuant to the Background Hydrogeochemical Characterization Monitoring Plan (BHCMP) (Rockwell International, 1989a). Described herein is a characterization of these media: surficial and bedrock materials; stream sediments; an initial round of ground-water samples, and; two rounds of surface water samples. This document identifies the appropriate statistical approach to compare background to non-background concentrations for each analyte, and provides calculated tolerance intervals for each analyte where possible.

The long-term goal of background hydrogeochemical characterization is evaluation of spatial and temporal variations in background ground-water and surface water quality. Spatial variations have been addressed by placing sample locations at several different locations across the plant. The goal of evaluating temporal variation cannot be achieved until multiple data sets for each media are available. This report covers only the first round of background ground-water samples and two rounds of surface water samples.

2.2 BACKGROUND

The Rocky Flats Plant (RFP) is a Department of Energy (DOE) facility involved in the manufacture of components for nuclear weapons. The Plant fabricates the components from plutonium, uranium, beryllium, and stainless steel. Both radioactive and nonradioactive wastes are generated in the process. Current waste handling practices involve on-site and off-site recycling of hazardous materials and off-site disposal of solid radioactive materials at another DOE facility. However, both storage and disposal of hazardous and radioactive wastes have occurred and are occurring on site. Preliminary assessments under the DOE Comprehensive Environmental Assessment and Response Program (now called the Environmental Restoration (ER) Program) identified past on-site storage and disposal locations as potential sources of environmental contamination.

The ER Program is a comprehensive, phased program of site characterization, environmental monitoring, remedial investigations, risk assessments, feasibility studies, remedial/corrective actions, and site closures. The Program includes CERCLA, RCRA 3004u and RCRA closure projects. Draft remedial investigation (RI) and feasibility study (FS) reports, and RCRA closure plans have been submitted to EPA and CDH. However, owing to aggressive investigation/clean-up schedules, sufficient background characterization data have not been previously collected. Background data are necessary to identify which inorganic compounds, if any, may be indicative of contamination at the Rocky Flats Plant. Therefore, the final remedial investigation/feasibility study reports and closure plans will incorporate this background information.

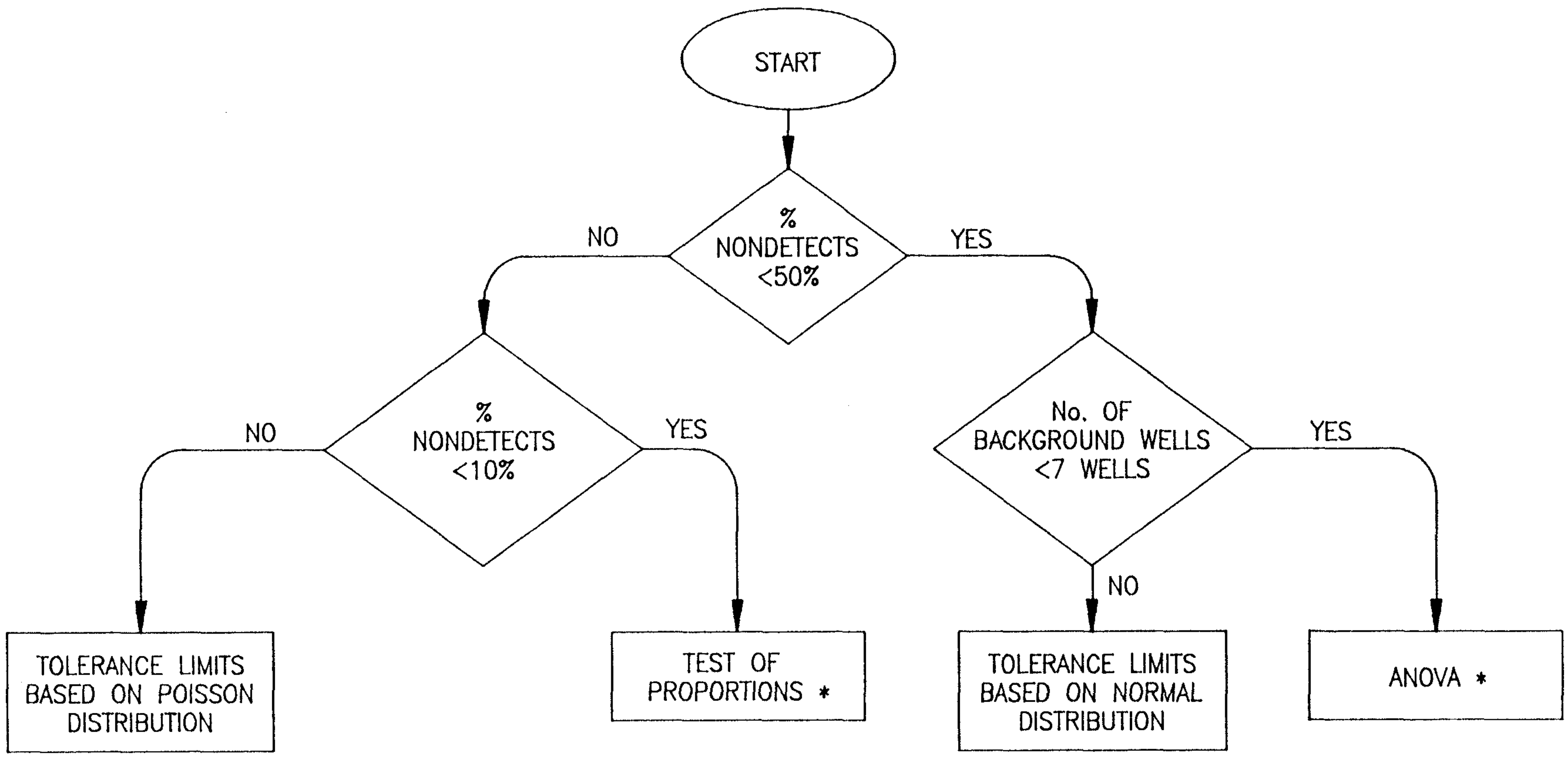
2.3 GENERAL APPROACH

In order to develop representative background data, samples were collected spatially across the Rocky Flats Property to characterize background variation within various media: surficial and bedrock materials, stream sediments, ground water, and surface water. In addition, samples were collected within subsets of some media based upon geological and hydrogeological considerations. For example ground water was sampled in Rocky Flats Alluvium, colluvium, valley fill alluvium, weathered sandstone and claystone, and unweathered sandstone.

The logic for selecting the appropriate method of statistical comparison between background and non-background is charted in Figure 2-1. As indicated within this flowchart, the primary determinant for use of the appropriate statistical method is the percentage of values above analytical detection limits. If there are less than 10% detects for a particular parameter, tolerance intervals based on the Poisson distribution are appropriate; if greater than 10% and less than 50% detects occur, a test of proportions is appropriate; and if greater than 50% detects are encountered, tolerance intervals or analysis of variance (ANOVA) are appropriate (EPA, 1989). Tolerance intervals will be calculated if the number of samples collected is equal to or greater than seven while ANOVA will be reserved for analytes when the number of samples collected is less than seven. The appropriate statistical procedure to be used for background/non-background comparative purposes, for each analyte within each subgroup, is identified in Section 4.0.

2.4 COMPUTATION OF NORMAL TOLERANCE INTERVAL STATISTICAL METHODS

A tolerance interval will be computed for a constituent concentration in a background soil or water type based on the latest quarterly data. (This will occur only once for soils and bedrock units as only one round of sampling is necessary to characterize background geochemistry). Tolerance intervals define a range that contains at least p% of a population with P% probability (level of confidence), i.e., upon repeated sampling, P% of the calculated intervals will contain p% of the population. Tolerance intervals answer the question: where do most of the observations lie?



* THIS STATISTICAL METHOD REQUIRES NONBACKGROUND SAMPLES

FIGURE 2-1

STATISTICAL METHODS FOR THE
EVALUATION OF BACKGROUND SAMPLES

R33022.MB-120689

For the tolerance interval to be useful in decision making, both "p" and "P" are chosen to be large, in this case, p = 0.95 and P = 0.95. A site-related or downgradient concentration that lies outside this interval will be evaluated as a potential release from a site/unit.

A tolerance interval is either one-sided or two-sided. A two-sided tolerance interval is appropriate whenever a concentration either larger or smaller than background may be associated with a contaminant release, e.g., pH. One-sided tolerance intervals are appropriate for all other constituents for which an increase over background concentrations are indicative of releases. A two-sided interval is defined by two limits (L_1 and L_2) where a proportion "p" of the population is contained between the limits L_1 and L_2 with probability "P". An upper (or lower) one-sided tolerance limit is defined so that P% of the population is less than (or greater than) the upper limit L_2 (or the lower limit L_1).

Criteria for the use of tolerance intervals based on normal distribution are (1) a 50% or greater rate of detection among samples (EPA, 1989), and (2) a sample size of seven or more. Tolerance interval calculations have been restricted to seven or more samples in order to obtain a 95 percent interval (95% of the population within a one-sided interval) with a tolerance factor of 3.4 (one-sided) at the 95% confidence level (Table 2-1). (The BHCMP calls for nine samples to achieve a tolerance factor of 3.0; however, for preliminary use, if seven samples are available a tolerance interval will be calculated). When a sample set size was less than seven, the mean plus three standard deviations were calculated for comparison with other tolerance intervals. When comparing these values, it must be emphasized that the mean plus three standard deviations reflects less than a 95% confidence level and/or less than 95% of the population.

Parametric tolerance intervals are calculated assuming a normal probability distribution. Assumption of a normal probability distribution is consistent with new EPA regulations for RCRA ground-water monitoring (EPA, 1988). If a given constituent's concentration ranges over more than three orders of magnitude, then a log normal tolerance interval will be used (Doctor, Gilbert, and Kinnison, 1986). The other criterion used to determine if the data was normally distributed was the calculation of the coefficient of variation. The coefficient of variation is the standard deviation divided by the mean (or adjusted mean as developed by Cohen, 1961). If the coefficient of variation resulted in a value greater than one or less than zero, the data is assumed to be lognormally distributed; therefore, lognormal tolerance intervals are proposed.

The lower and upper limits of a normal population tolerance interval are computed as:

$L_1 = \overline{x} - Ks$ and

$L_2 = \overline{x} + Ks$;

where:

$\overline{x}$ = mean of the sample population of size n;

s = standard deviation of the sample population; and

K = the normal tolerance factor [dependent on p, P, n (the number of samples), and on whether the interval is one- or two-sided].

Table 2-1 presents tolerance factors K for two-sided and one-sided tolerance intervals at 95% population and 95% confidence. With the exception of pH, one sided tolerance intervals (L_2) will be calculated for all analytes. For a small number of samples, the K value is large leading to tolerance intervals that probably would not detect releases from sites/units. As the number of samples increases, the value of K decreases, which leads to narrower tolerance intervals. Narrower background tolerance intervals will be more sensitive to detecting releases to the environment from sites/units.

Many Inorganic Target Analyte List constituents will be undetected in both background and downgradient wells. Special procedures are thus needed to compute the mean and standard deviation of a population when a significant number of the observations are below the detection limit. A data set is termed censored when not detected (ND) observations are present in a data set, and some assumption must be made about the statistical distribution

TABLE 2-1

TOLERANCE FACTORS FOR NORMAL TOLERANCE LIMITS FOR 95% POPULATION AT 95% CONFIDENCE

n	Two-Sided	One-Sided
2	37.67	
3	9.916	7.655
4	6.370	5.145
5	5.079	4.202
6	4.414	3.707
7	4.007	3.399
8	3.732	3.188
9	3.532	3.031
10	3.379	2.911
11	3.259	2.815
12	3.162	2.736
13	3.081	2.670
14	3.012	2.614
15	2.954	2.566
16	2.903	2.523
17	2.858	2.486
18	2.819	2.453
19	2.784	2.423
20	2.752	2.396
21	2.723	2.371
22	2.697	2.350
23	2.673	2.329
24	2.651	2.309
25	2.631	2.292
26	2.612	
27	2.595	
28	2.579	
29	2.554	
30	2.549	2.220
35	2.490	2.166
40	2.445	2.126
45		2.092
50	2.379	2.065
60	2.333	
80	2.272	
100	2.233	
200	2.143	
500	2.070	
1000	2.036	
inf.	1.960	

for the entire data set. A technique for calculation of the mean and standard deviation of such a data set was developed by Cohen (1961) and can be used if the data are normally distributed.

The Cohen procedure is as follows (Doctor, Gilbert, and Kinnison, 1986).

Let:

n = the total number of observations for a constituent;

k = number of actual measurements out of n (not NDs); and

x_o = the detection limit of the constituent.

Then:

1) Compute $h = (n-k)/n$ (the proportion of measurements below the detection limit);

2) Compute x_u = (Sum of x_i for $i = 1$ to k)/k;

3) Compute s^2_u = (Sum of $(x_i - x_u)^2$ for $i = 1$ to k)/k;

4) Compute $t = s^2_u/(x_u-x_o)^2$;

5) Obtain an estimate of Lambda from Table 2-2 using h and t;

6) Estimate the mean and variance of the population from which the censored data set was drawn by computing

$$x = x_u - \lambda 2\,(x_u-x_o)$$

and $$s = [s^2_u + \lambda 2\,(x_u-x_o)^2]^{1/2}.$$

With regard to radiochemistry data, a measurement error, equal to 2 standard deviations (2s) of the measurement is associated with the results. It is necessary to consider propagation of error when interpreting the mean value computed from a series of radiochemical results, i.e., the precision of each measurement must be considered in order to define the precision of the mean value. This is accounted for by computing the variance (s^2) of the mean value.

It is noted that the variance of the sum of n observations each with variance s^2_{xi} is simply the sum of the variances.

$$y = x_i + x_{i+1} + \ldots x_n$$

$$s^2_y = s^2_{xi} + s^2_{xi+1} + \ldots s^2_n$$

When coefficients are involved, the relationship is as follows:

$$y = ax_c + bx_{c+1} + \ldots kx_n$$

$$s^2_y = a^2s^2_{xi} + b^2s^2_{xi+1} + \ldots k^2s^2_{xn}$$

Computation of mean implies the coefficients are each equal to 1/n. Therefore the variance of the mean is

$$s^2_x = 1/n^2 \; (s^2_{xi} + s^2_{xi+1} + \ldots s^2_n)$$

The relationship has been used to calculate the error associated with the mean, where the error is $2s_x$.

TABLE 2-2

Values of Lambda for Estimating the Mean and Variance of a Normal Distribution when ND Values are Present

h Tau	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.15	.25>	h Tau
0.00	0.010100	0.020400	0.030902	0.041583	0.052507	0.063627	0.074953	0.086488	0.098240	0.110200	0.173420	0.242680	0.00
0.05	0.010551	0.021294	0.032225	0.043350	0.054670	0.066189	0.077909	0.089634	0.101970	0.114310	0.179350	0.250330	0.05
0.10	0.010950	0.022082	0.033398	0.044902	0.056596	0.068483	0.080568	0.092852	0.105340	0.118040	0.184790	0.257410	0.10
0.15	0.011310	0.022798	0.034466	0.046318	0.058356	0.070586	0.083009	0.095629	0.108450	0.121480	0.189650	0.264050	0.15
0.20	0.011642	0.023459	0.035453	0.047629	0.059990	0.072539	0.085280	0.098216	0.111350	0.124690	0.194600	0.270310	0.20
0.25	0.011952	0.024076	0.036377	0.048858	0.061522	0.074372	0.087413	0.100650	0.114080	0.127720	0.199100	0.276260	0.25
0.30	0.012243	0.024658	0.037249	0.050018	0.062969	0.076106	0.089433	0.102950	0.116670	0.130590	0.203380	0.281930	0.30
0.35	0.012520	0.025211	0.038077	0.051120	0.064345	0.077756	0.091355	0.105150	0.119140	0.133330	0.207470	0.287370	0.35
0.40	0.012784	0.025738	0.038866	0.052173	0.065660	0.079332	0.093193	0.107250	0.121500	0.135950	0.211390	0.292600	0.40
0.45	0.013036	0.026243	0.039624	0.053182	0.066921	0.080845	0.094958	0.109260	0.123770	0.138470	0.215170	0.297650	0.45
0.50	0.013279	0.026728	0.040352	0.054153	0.068135	0.082301	0.096657	0.111210	0.125950	0.140900	0.218820	0.302530	0.50
0.55	0.013513	0.027196	0.041054	0.055089	0.069306	0.083708	0.098298	0.113080	0.128060	0.143250	0.222350	0.307250	0.55
0.60	0.013739	0.027649	0.021733	0.055995	0.070439	0.085068	0.099887	0.114900	0.130110	0.145520	0.225780	0.311840	0.60
0.65	0.013958	0.028087	0.042391	0.056874	0.071538	0.086388	0.101430	0.116660	0.132090	0.147730	0.229100	0.316300	0.65
0.70	0.014171	0.028513	0.043030	0.057726	0.072605	0.087670	0.102920	0.118370	0.134020	0.149870	0.232340	0.320650	0.70
0.75	0.014378	0.028927	0.043652	0.058556	0.073643	0.088917	0.104380	0.120040	0.135900	0.151960	0.235500	0.324890	0.75
0.80	0.014579	0.029330	0.044258	0.059364	0.074655	0.090133	0.105800	0.121670	0.137730	0.154000	0.238580	0.329030	0.80
0.85	0.014775	0.029723	0.044848	0.060153	0.075642	0.091319	0.107190	0.123250	0.139520	0.155990	0.241580	0.333070	0.85
0.90	0.014967	0.030107	0.045425	0.060923	0.076606	0.092477	0.108540	0.124800	0.141260	0.157930	0.244520	0.337030	0.90
0.95	0.015154	0.030483	0.045989	0.061676	0.077549	0.093611	0.109870	0.126320	0.142970	0.159830	0.247400	0.340910	0.95
1.00	0.015338	0.030850	0.046540	0.062413	0.078471	0.094720	0.111160	0.127800	0.144650	0.161700	0.250220	0.344710	1.00

TABLE 2-2
(continued)

Values of Lambda for Estimating the Mean and Variance of a Normal Distribution when ND Values are Present

h Tau	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.80	.90	h Tau
0.00	0.318620	0.402100	0.494100	0.596100	0.709600	0.836800	0.980800	1.145000	1.336000	1.561000	2.176000	3.283000	0.00
0.05	0.327930	0.413000	0.506600	0.610100	0.725200	0.854000	0.999400	1.166000	1.358000	1.585000	2.203000	3.314000	0.05
0.10	0.336620	0.423300	0.518400	0.623400	0.740000	0.870300	1.017000	1.185000	1.379000	1.608000	2.229000	3.345000	0.10
0.15	0.344800	0.433000	0.529600	0.636100	0.754200	0.886000	1.035000	1.204000	1.400000	1.630000	2.255000	3.376000	0.15
0.20	0.352550	0.442200	0.540300	0.648300	0.767800	0.901200	1.051000	1.222000	1.419000	1.651000	2.280000	3.405000	0.20
0.25	0.359930	0.451000	0.550600	0.660000	0.781000	0.915800	1.067000	1.240000	1.439000	1.672000	2.305000	3.435000	0.25
0.30	0.367000	0.459500	0.560400	0.671300	0.793700	0.930000	1.083000	1.257000	1.457000	1.693000	2.329000	3.464000	0.30
0.35	0.373790	0.467600	0.569900	0.682100	0.806000	0.943700	1.098000	1.274000	1.476000	1.713000	2.353000	3.492000	0.35
0.40	0.380330	0.475500	0.579100	0.692700	0.816900	0.957000	1.113000	1.290000	1.494000	1.732000	2.376000	3.520000	0.40
0.45	0.386630	0.483100	0.588000	0.702900	0.829500	0.970000	1.127000	1.306000	1.511000	1.751000	2.399000	3.547000	0.45
0.50	0.392760	0.490400	0.596700	0.712900	0.840800	0.982600	1.141000	1.321000	1.528000	1.770000	2.421000	3.575000	0.50
0.55	0.398700	0.497600	0.605100	0.722500	0.851700	0.995000	1.155000	1.337000	1.545000	1.788000	2.443000	3.601000	0.55
0.60	0.404470	0.504500	0.613300	0.732000	0.862500	1.007000	1.169000	1.351000	1.561000	1.806000	2.465000	3.628000	0.60
0.65	0.410080	0.511400	0.621300	0.741200	0.872900	1.019000	1.182000	1.366000	1.557000	1.824000	2.486000	3.654000	0.65
0.70	0.415550	0.518000	0.629100	0.750200	0.883200	1.030000	1.195000	1.380000	1.593000	1.841000	2.507000	3.679000	0.70
0.75	0.420900	0.524500	0.636700	0.759000	0.893200	1.042000	1.207000	1.394000	1.608000	1.858000	2.528000	3.705000	0.75
0.80	0.426120	0.530800	0.644100	0.767600	0.903100	1.053000	1.220000	1.408000	1.624000	1.875000	2.548000	3.730000	0.80
0.85	0.431220	0.537000	0.651500	0.776100	0.912700	1.064000	1.232000	1.422000	1.639000	1.892000	2.568000	3.754000	0.85
0.90	0.436220	0.543000	0.658600	0.784400	0.922200	1.074000	1.244000	1.435000	1.653000	1.908000	2.588000	3.779000	0.90
0.95	0.441120	0.549000	0.665600	0.792500	0.931400	1.085000	1.255000	1.448000	1.668000	1.924000	2.607000	3.803000	0.95
1.00	0.445920	0.554800	0.672400	0.800500	0.940600	1.095000	1.267000	1.461000	1.682000	1.940000	2.626000	3.827000	1.00

SECTION 3.0

SAMPLING LOCATIONS AND SAMPLE COLLECTION

In order to identify changes in site soil and water chemistry due to Plant operations, background conditions in soil and water are being evaluated. Fifty monitoring wells were installed during this program and nine stations were selected for collection of surface water and sediment samples (Plate 1). In addition, samples were collected from eighteen boreholes for chemical analysis.

All ground-water, surface water, borehole, and sediment sampling activities were conducted in accordance with the ER Program Standard Operating Procedures (SOPs) for Rocky Flats Plant (Rockwell International, 1989b). Laboratory analyses of the samples were performed following Contract Laboratory Program (CLP) protocols for the Inorganic Target Analyte List. Details of laboratory analyses for these and other constituents are presented in the Quality Assurance/Quality Control (QA/QC) Plan (Rockwell International, 1989c). Also presented in the QA/QC plan are the guidelines used during the Background Field Program for collection of QA/QC samples (field/equipment blanks, and field duplicates).

3.1 GROUND WATER

Two ground-water flow systems have been identified within the Rocky Flats Plant; a surficial flow system within the Rocky Flats Alluvium, colluvium, valley fill and weathered bedrock, and a bedrock flow system within unweathered bedrock sandstones (Figure 3-1). The hydraulic connection between the two flow systems are the bedrock sandstones which subcrop beneath surficial materials. Ground-water flow for both systems is generally west to east, although ground-water flow in the surficial system is locally determined by topography. Ground water within the Rocky Flats Alluvium moves downslope into colluvium and then into valley fill. Ground water from the Rocky Flats Alluvium recharges weathered bedrock, and also the bedrock flow system where the weathered bedrock includes subcropping sandstones.

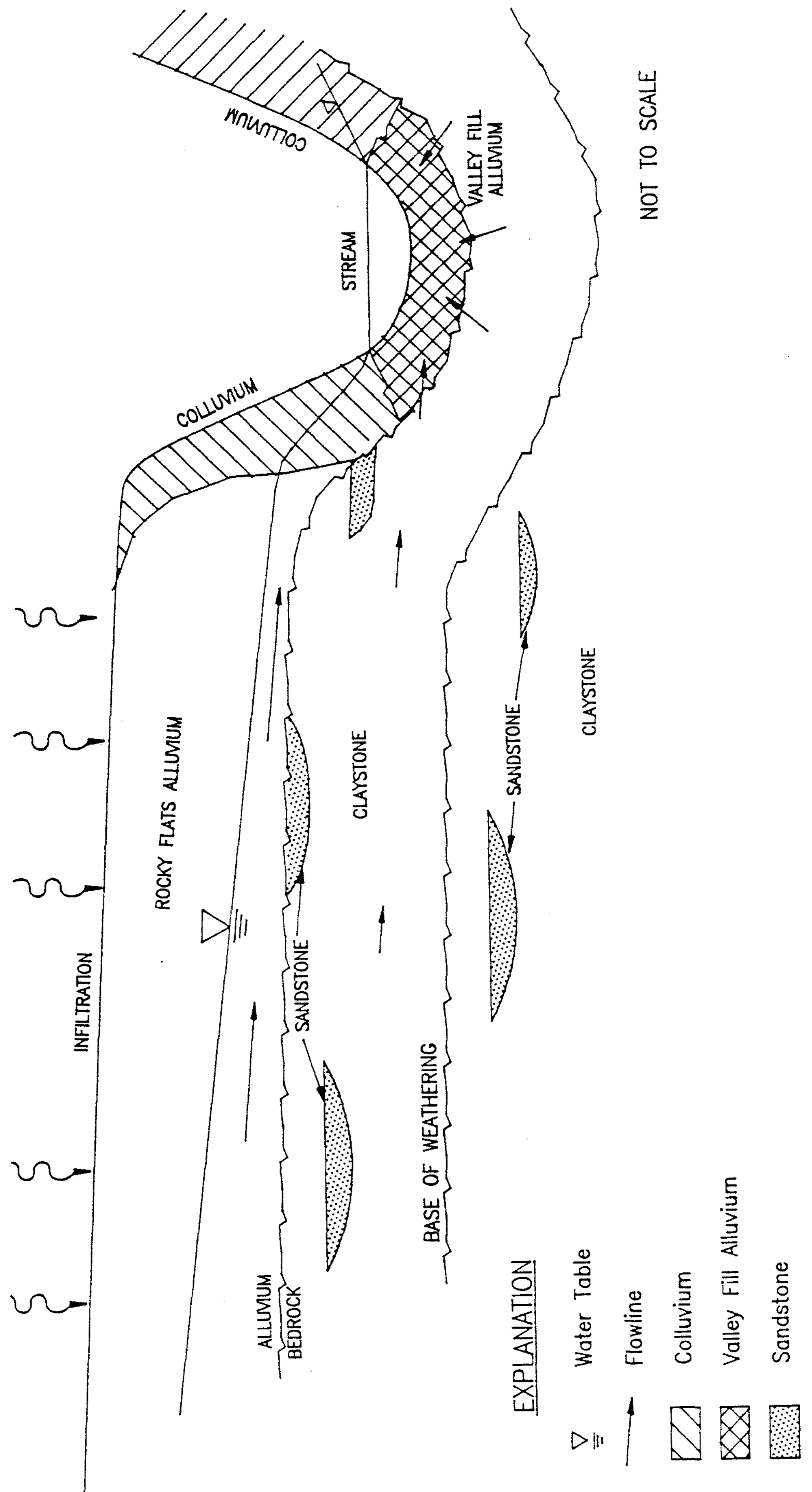


FIGURE 3—1

SCHEMATIC OF GROUND WATER/SURFACE WATER INTERACTION

Samples collected from fifty-one ground-water monitoring wells (fifty wells installed in 1989 and one well installed in 1986) at the Rocky Flats Plant were analyzed to characterize background ground-water quality (Table 3-1). Also shown in Table 3-1 are the completion units for each of the background monitoring wells. Wells were completed in the alluvium, colluvium, valley fill alluvium, and weathered and unweathered bedrock.

Results of the first round (Round 1) of ground-water samples are presented in this report. Round 1 began on April 4, 1989 and was completed on July 17, 1989. A total of 35 samples were collected from the fifty-one wells as shown in Table 3-2. Eight colluvial wells, one valley fill alluvium well, six weathered claystone wells, and one unweathered sandstone well were dry during the Round 1 sampling effort. A well was considered dry if the water level in the well was below the base of the screen prior to the pre-sample purge. The samples collected were analyzed for the parameters listed in Table 3-3. Contract Laboratory Program (CLP) Target Compound List (TCL) organics do not occur naturally and should not be present in background ground water. Therefore, they were not included in the analyte list.

3.1.1 Rocky Flats Alluvium Ground Water

Alluvial ground water was characterized by sampling alluvial wells installed in eight borings used for characterization of the Rocky Flats Alluvium (Wells B400189, B400289, B400389, B400489, B200589, B200689, B200789 and B200889). Well B405586 serves as the ninth background alluvial well (Plate 1). The wells were installed in two different areas of the Plant Buffer Zone to account for spatial variability. Wells B405586, B400189, B400289, B400389 and B400489 were installed in the southwest portion of the buffer zone in an area which exhibits lithologies similar to the West Spray Field. Wells B200589, B200689, B200789, and B200889 were installed in the northern buffer zone sidegradient of the Plant due to expected similarities in lithology and saturated thicknesses to those at the Solar Evaporation Ponds, 903 Pad, Mound, and East Trenches Areas.

TABLE 3-1

BACKGROUND WELL DATA FOR ROCKY FLATS PLANT

Well Number	Well Status	Depth to Top of Screen (ft)	Depth to Bottom of Screen (ft)	Total Depth (ft)	Depth to Bedrock (ft)	Geologic Strata of Complete.
B400189	1	10.09	49.60	51.35	49.80	Qrf
B400289	1,5	20.52	50.00	51.25	49.60	Qrf
B400389	1,5	9.50	49.00	50.30	48.50	Qrf
B400489	1,5	9.87	54.45	55.70	54.00	Qrf
B200589	1,5	11.86	31.57	33.31	30.00	Qrf
B200689	1,5	11.58	31.05	32.80	30.60	Qrf
B200789	1,5	9.07	28.50	30.47	28.00	Qrf
B200889	1,5	8.60	23.12	24.70	22.80	Qrf
B201089	1,5	3.48	7.83	9.60	7.50	Qc
B201189	1,5	20.36	34.80	36.50	34.00	Qc
B201289	1,5	14.73	23.90	26.11	23.40	Qc
B201489	1,5	5.58	9.96	11.64	7.00	Qc
B201589	1,5	4.38	8.76	10.50	8.20	Qc
B301889	1,5	13.16	22.60	24.45	22.30	Qc
B401989	1,5	6.55	21.00	22.65	20.50	Qc
B302089	1,5	3.85	13.30	15.00	13.50	Qc
B402189	1,5	13.50	22.90	24.60	7.50	Kss
B102289	1	3.00	12.47	14.22	12.50	Qvf
B102389	1	3.74	10.90	12.61	10.40	Qvf
B202489	1	3.43	12.90	14.65	12.40	Qvf
B202589	1	4.53	11.60	13.40	11.20	Qvf
B402689	1	2.55	3.28	5.85	2.80	Qvf
B302789	1	4.00	8.55	10.17	8.00	Qvf
B302889	1	5.92	10.52	12.10	10.20	Qvf
B302989	1	3.46	7.90	9.65	7.40	Qvf
B303089	1	4.61	7.00	8.90	6.60	Qvf
B203189	1	35.26	44.70	46.47	30.30	Kcl
B203289	1	35.00	44.47	46.00	30.10	Kcl
B203489	1	31.00	40.50	41.25	28.60	Kcl
B203589	1	29.70	39.16	40.94	24.30	Kcl
B203689	4	27.05	36.55	37.30	22.60	Kcl
B203789	1	134.15	138.59	140.84	26.70	Kss
B203889	1	107.00	111.43	113.90	28.40	Kss
B203989	1	125.97	130.42	132.70	23.70	Kss
B204089	1	106.50	112.90	115.23	1.60	Kss
B204189	1	81.10	95.33	97.62	3.70	Kss
B304289	1	84.40	88.49	90.95	10.50	Kss
B204689	4	105.50	109.95	112.22	2.90	Kss
B304789	1	27.90	37.57	39.14	22.90	Kcl
B304889	1	14.66	24.14	25.90	9.70	Kcl
B304989	1	75.50	82.87	86.25	8.40	Kss
B405189	1	13.20	22.69	24.45	8.20	Kcl
B405289	1	41.24	45.67	48.00	10.30	Kss
B305389	1	15.18	25.00	26.30	10.00	Kcl
B405489	1	39.13	48.57	50.05	34.00	Kcl
B205589	1	6.87	16.30	18.00	32.30	Qc
B405689	1	3.00	22.51	23.75	0.00	Qrf
B405789	1	43.01	52.48	53.72	52.00	Qrf
B405889	1	36.04	45.50	46.75	6.50	Kss
B405989	1	2.80	6.70	8.50	6.20	Qc
B405586	1	3.55	36.39	36.39	35.50	Qrf

KEY TO STATUS: 1 - Active Well; 2 - Abandoned Borehole; 3 - Abandoned Well;
4 - Inactive Well; 5 - Borehole Sampled; 6 - Observation Well

KEY TO GEOLOGIC STRATA: Qrf-Rocky Flats Alluvium; Qc-Colluvium; Qvf-Valley Fill Alluvium; Kcl-Weathered Claystone; Kss-Sandstone

TABLE 3-2

BACKGROUND GROUND-WATER

	SAMPLE INFORMATION		FIELD PARAMETERS		
WELL NUMBER	SAMPLE NUMBER	SAMPLE DATE	pH	FIELD COND. (umhos/cm)	TEMP. (deg.C)
B102289	G18890489001	04/25/89	7.00	130.0	10.0
B102389	G19890489001	04/25/89	6.70	250.0	9.0
B200589	G05890689001	06/07/89	7.00	150.0	10.5
B200689	G06890689001	06/07/89	7.20	200.0	11.0
B200789	G07890689001	06/06/89	7.40	220.0	11.0
B200889	G08890689001	06/05/89	8.60	205.0	12.2
B201089	DRY	04/19/89	N/A	N/A	N/A
B201189	G10890589001	05/05/89	7.20	550.0	10.0
B201289	DRY	05/15/89	N/A	N/A	N/A
B201489	DRY	05/15/89	N/A	N/A	N/A
B201589	DRY	05/12/89	N/A	N/A	N/A
B202489	G20890489001D	04/24/89	7.00	265.0	12.0
B202489	G20890489001	04/24/89	7.00	265.0	12.0
B202589	G21890489001	04/26/89	7.30	265.0	11.0
B203189	DRY	05/24/89	N/A	N/A	N/A
B203289	G28890689001	06/20/89	8.00	400.0	15.0
B203489	DRY	05/25/89	N/A	N/A	N/A
B203589	DRY	05/22/89	N/A	N/A	N/A
B203689	G31890589001	05/25/89	7.80	230.0	11.0
B203689	G31890589001D	05/25/89	7.80	230.0	11.0
B203789	G32890689001	06/27/89	10.00	260.0	12.0
B203889	G33890789001	06/29/89	9.80	340.0	20.0
B203989	G34890689001	06/16/89	9.00	320.0	13.0
B204089	G35890789001	07/06/89	9.70	1000.0	17.0

*FB: *Field Blank*

TABLE 3-2 (CONTINUED)

BACKGROUND GROUND-WATER SAMPLE INFORMATION

	SAMPLE INFORMATION		FIELD PARAMETERS		
WELL NUMBER	SAMPLE NUMBER	SAMPLE DATE	pH	FIELD COND. (umhos/cm)	TEMP. (deg.C)
B204189	G36890689001	06/27/89	10.40	1800.0	12.0
B205589	DRY	05/05/89	N/A	N/A	N/A
B301889	DRY	05/11/89	N/A	N/A	N/A
B302089	DRY	05/16/89	N/A	N/A	N/A
B302789	G23890489001	04/26/89	7.50	370.0	10.0
B302889	G24890489001	04/27/89	7.50	410.0	11.0
B302989	G25890489001	04/27/89	7.50	475.0	9.0
B303089	DRY	05/10/89	N/A	N/A	N/A
B304289	G37890689001	06/23/89	9.00	760.0	21.0
B304789	DRY	05/24/89	N/A	N/A	N/A
B304889	DRY	05/22/89	N/A	N/A	N/A
B304989	G41890689001	06/23/89	8.90	890.0	21.0
B305389	G44890589001	05/31/89	7.30	570.0	12.0
B400189	G01890689001	06/14/89	6.60	140.0	11.0
B400289	G02890689001	06/14/89	6.70	160.0	11.5
B400389	G03890689001	06/14/89	7.40	380.0	11.5
B400489	G04890689001	06/15/89	7.00	210.0	13.0
B401989	G15890589001	05/04/89	7.10	340.0	9.0
B401989	G15890589001D	05/04/89	7.10	340.0	9.0
B402189	G17890689001	06/05/89	8.40	345.0	10.0
B402689	G22890489001	04/27/89	7.10	500.0	14.0
B405189	DRY	05/24/89	N/A	N/A	N/A
B405289	DRY	06/23/89	N/A	N/A	N/A
B405489	G45890689001	06/21/89	8.10	325.0	23.0

*FB: Field Blank

TABLE 3-2 (CONTINUED)

BACKGROUND GROUND-WATER SAMPLE INFORMATION

	SAMPLE INFORMATION		FIELD PARAMETERS		
WELL NUMBER	SAMPLE NUMBER	SAMPLE DATE	pH	FIELD COND. (umhos/cm)	TEMP. (deg.C)
B405586	G55860689001	06/08/89	7.10	180.0	11.0
B405689	G47890689001	06/14/89	7.50	340.0	11.0
B405789	G48890689001	06/15/89	7.00	190.0	13.0
B405889	G49890689001	06/14/89	7.00	250.0	9.0
B405889	G49890689001D	06/14/89	7.00	250.0	9.0
B405989	DRY	05/17/89	N/A	N/A	N/A
FB	G20890489001FB	04/24/89	N/A	N/A	N/A
FB	G10890589001FB	05/05/89	N/A	N/A	N/A
FB	G31890589001FB	05/25/89	N/A	N/A	N/A
FB	G49890689001FB	06/14/89	N/A	N/A	N/A

*FB: Field Blank

TABLE 3-3

BACKGROUND GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

FIELD PARAMETERS

pH
Specific Conductance
Temperature
Dissolved Oxygen*

INDICATORS

Total Dissolved Solids
Total Suspended Solids*
pH

METALS**

CLP Inorganic Target Analyte List
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc

Other Metals
- Cesium
- Lithium
- Molybdenum
- Strontium
- Tin

TABLE 3-3 (CONTINUED)

BACKGROUND GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

ANIONS

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate (as N)
Cyanide

RADIONUCLIDES

Gross Alpha
Gross Beta
Uranium 233+234, 235, and 238
Americium 241
Plutonium 239+240
Strontium 90
Cesium 137
Tritium
Radium 226, 228***

* For surface water samples only.

** Analysis for total and dissolved metals for surface water. Analysis for total (Rounds 1 and 2) and dissolved (Round 1 only) radionuclides (except tritium) on surface water. Analysis for dissolved metals and radionuclides (except tritium) only for ground water. Analysis for total tritium only in surface water and ground water.

*** Decision tree. If the Gross Alpha value was ≥ 5 pCi/l then the sample was analyzed for Ra 226,228.

In addition to the above alluvial background wells, one well cluster was installed in the Rocky Flats Alluvium at the location where the greatest saturated thickness was encountered. The purpose of this cluster is to evaluate geochemical stratification of alluvial ground-water quality west of the Plant. This will aid in the interpretation of potential geochemical stratification and impacts on ground-water quality from the West Spray Field. The well cluster consists of three wells constructed on the basis of the saturated thickness encountered during drilling. Well B400489 was screened over the entire saturated thickness of the Rocky Flats Alluvium (9.87 to 54.45 feet below ground surface). Well B405789 located approximately 15 feet west of B400489 and was screened over the bottom ten feet of saturated alluvium (43.01 to 52.48 feet below ground surface) and Well B405689, installed approximately 15 feet east of B400489, was screened from ten feet above to ten feet below the water level (3.0 to 22.51 feet below ground surface).

3.1.2 Colluvial Ground Water

Ten wells were installed in colluvial materials to account for spatial variability. Wells B201089, B201189, B201289, B201489, B201589 and B205589 were installed in the north buffer, whereas Wells B301889, B401989, B302089 and B405989 were installed in the south buffer zone (Plate 1). There are no waste sites/units in either of these areas.

3.1.3 Valley Fill Alluvium Ground Water

Valley fill ground-water quality was characterized by sampling nine wells installed in valley fill materials (Plate 1). Wells B102289, B102389, B202489 and B202589 were installed at four locations along the Rock Creek drainage, and five additional wells were installed in the Woman Creek drainage and other unnamed drainages in the south buffer (B402689, B302789, B302889, B302989 and B303089) to characterize spatial variability along and between drainages. None of the above areas have been impacted by waste sites/units.

3.1.4 Bedrock Ground Water

Data for the characterization of background bedrock ground-water quality were collected by installing and sampling 21 monitoring wells screened in bedrock. These wells were drilled in various areas of the Plant buffer zone (Plate 1).

Eleven bedrock wells were completed in the northern buffer zone. Five of the eleven wells (B303189, B203289, B203489, B203589 and B203689) were installed adjacent to the sidegradient northern alluvial wells and were completed in weathered claystone. The remaining six wells (B203789, B203889, B203989, B204089, B204189 and B204689) were completed in unweathered sandstones.

Ten bedrock wells were installed in the southern buffer zone. Three were completed in unweathered sandstones (Wells B304289, B304989, and B405289), five were completed in shallow, weathered claystone (Wells B304789, B304889, B405189, B305389, and B405489), and two (B402189 and B405889) were completed in weathered sandstones.

3.2 SURFACE WATER

Nine surface water monitoring locations were selected as background stations (Plate 1 and Table 3-4). One station (SW-107) is located in the Woman Creek drainage upstream of all sites/units. Three stations (SW-41, SW-80, and SW-104) are positioned within tributaries entering Woman Creek from the southwest. Station SW-07 is situated in a tributary of Walnut Creek and stations SW-06, SW-05, SW-108, and SW-04 are located along the Rock Creek drainage. Analytical data from the first two rounds of sampling are included in this report. The first round of samples was collected between 2/24/89 and 3/2/89 with all nine stations sampled (Table 3-5). The second round of samples was collected on 5/8/89 through 6/1/89 and two stations (SW-80 and SW-04) were dry (Table 3-6). Additional rounds are being collected to evaluate seasonal variations in surface water chemistry.

TABLE 3-4

BACKGROUND SURFACE WATER AND SEDIMENT STATION DATA FOR ROCKY FLATS PLANT

Surface Water Station Number	Sediment Station Number	Location
SW004	SED 22	Rock Creek Drainage
SW005	SED 20	Rock Creek Drainage
SW006	SED 23	Rock Creek Drainage
SW007	SED 04	Tributary of Walnut Creek
SW041	SED 17	Tributary of Woman Creek
SW080	SED 18	Tributary of Woman Creek (spring)
SW104	SED 19	Tributary of Woman Creek (spring)
SW107	SED 16	Woman Creek Drainage
SW108	SED 21	Rock Creek Valley Wall

TABLE 3-5

BACKGROUND SURFACE WATER SAMPLE INFORMATION
ROUND 1

	SAMPLE INFORMATION		FIELD PARAMETERS			
STATION NUMBER	SAMPLE NUMBER	SAMPLE DATE	pH	FIELD COND. (umhos/cm)	TEMP. (deg.C)	D.O. (mg/l)
FB	SW06001FB	02/24/89	N/A	N/A	N/A	N/A
SW04	SW004001	03/02/89	6.50	210.00	3.0	7.0
SW05	SW05001	02/28/89	6.28	150.00	2.7	4.0
SW06	SW06001	02/24/89	6.45	60.00	4.0	3.1
SW06	SW06001D	02/24/89	6.45	60.00	4.0	3.1
SW07	SW07001	02/27/89	6.40	130.00	5.0	1.3
SW104	SW104001	03/02/89	5.90	410.00	1.0	3.0
SW107	SW107001	02/28/89	5.60	190.00	0.5	5.3
SW108	SW108001	03/02/89	5.80	285.00	1.0	7.4
SW41	SW41001	03/01/89	5.00	200.00	0.5	5.5
SW80	SW080001	03/01/89	6.00	160.00	0.6	3.8

*FB: Field Blank

TABLE 3-6

BACKGROUND SURFACE WATER SAMPLE INFORMATION
ROUND 2

	SAMPLE INFORMATION		FIELD PARAMETERS			
STATION NUMBER	SAMPLE NUMBER	SAMPLE DATE	pH	FIELD COND. (umhos/cm)	TEMP. (deg.C)	D.O. (mg/l)
FB	SW108002FB	05/30/89	N/A	N/A	N/A	N/A
SW04	DRY	05/30/89	N/A	N/A	N/A	N/A
SW05	SW005002	05/30/89	7.20	70.00	12.0	3.4
SW06	SW006002	05/31/89	7.00	90.00	14.0	4.5
SW07	SW007002	05/31/89	6.50	285.00	15.0	5.9
SW104	SW104002	06/01/89	7.50	140.00	14.0	5.3
SW107	SW107002	05/26/89	7.50	192.00	21.0	3.2
SW108	SW108002	05/30/89	7.40	300.00	13.0	0.0
SW108	SW108002D	05/30/89	7.40	300.00	13.0	0.0
SW41	SW041002	05/26/89	6.80	165.00	19.0	0.0
SW80	DRY	05/24/89	N/A	N/A	N/A	N/A

*FB: Field Blank

Laboratory analyses on background surface water samples consisted of the parameters listed in Table 3-3. Surface water samples were analyzed in the field for pH, conductivity, temperature, and dissolved oxygen (Table 3-2).

3.3 STREAM SEDIMENT

Background stream sediment chemistry was evaluated by sampling nine sediment monitoring locations for subsequent chemical analyses (Plate 1 and Table 3-4). These stations are paired with the background surface water stations described above. Stations SED-20, SED-21, SED-22, and SED-23 are located in the Rock Creek drainage; station SED-04 is located in Walnut Creek; and stations SED-16, SED-17, SED-18, and SED-19 are located in Woman Creek. These sites were selected as locations representative of sediments present in the drainages on the plant site where impacts from sites/units are not anticipated.

Sample collection took place between 2/21/89 and 2/24/89 and a total of nine samples were collected (Table 3-7). The background sediment samples were analyzed for the parameters listed in Table 3-8.

3.4 BOREHOLE SAMPLES

Two major types of surficial materials (Rocky Flats Alluvium and Colluvium) have been identified at the Rocky Flats Plant. Many of the RCRA/CERCLA sites are situated on Rocky Flats Alluvium, including the Present Landfill, Original Process Waste Lines, West Spray Field, Solar Evaporation Ponds, 903 Pad Area, Mound Area, and East Trenches Areas. Colluvium is present in the previously mentioned investigation areas as well as in the 881 Hillside Area. Development of background borehole data therefore required sampling of both types of materials.

TABLE 3-7

BACKGROUND SEDIMENT SAMPLE INFORMATION

STATION NUMBER	SAMPLE INFORMATION	
	SAMPLE NUMBER	SAMPLE DATE
FB	SED22001FB	02/22/89
SD004	SED04001	02/21/89
SD004	SED04001D	02/21/89
SD016	SED16001	02/23/89
SD017	SED17001	02/23/89
SD018	SED18001	02/23/89
SD019	SED19001	02/23/89
SD020	SED20001	02/22/89
SD021	SED21001	02/22/89
SD022	SED22001	02/22/89
SD023	SED23001	02/21/89

*FB: Field Blank

TABLE 3-8

BACKGROUND SEDIMENT SAMPLING PARAMETERS

METALS

CLP Target Analyte List
Cesium
Lithium
Molybdenum
Strontium
Tin

INORGANICS

Nitrate (as N)
pH
% solids

RADIONUCLIDES

Gross Alpha
Gross Beta
Uranium 233, 234, 235, 238
Plutonium 239, 240
Americium 241
Strontium 89, 90
Cesium 137
Tritium
Radium 226, 228

In addition to surficial materials, bedrock underlies the surficial deposits at the Rocky Flats Plant, therefore characterization of the background geochemical conditions in these geologic units was conducted for comparison with investigative samples.

Borehole samples were collected from nine borings drilled in the Rocky Flats Alluvium and nine boreholes drilled in colluvial materials (Plate 1). Weathered bedrock samples were also collected from the boreholes drilled in the colluvium to characterize the weathered sandstone and claystone.

Several different areas of the plant were chosen in order to account for spatial variability of soil chemistry. Table 3-10 lists the survey data as well as the total depth and depth to bedrock for each borehole. Boreholes B400189, B400289, B400389, and B400489 were drilled in the southwestern buffer and boreholes B200589, B200689, B200789, B200889, and B200989 were drilled in the northern buffer zone. These boreholes were used to collect soil samples to characterize the geochemistry of the Rocky Flats Alluvium. Background samples from colluvial materials were collected in both the northern and southern buffer zones. Boreholes B201189, B201289, B201489, and B201589 were drilled along the Rock Creek valley walls and borehole B201089 was drilled along McKay Ditch. Boreholes B301889, B401989, B302089 and B402189 were drilled in the southern buffer along the south wall of Woman Creek.

Split-spoon, split-tube, or cuttings were collected from ground surface to total depth in each borehole. Composite soil samples were prepared from each desired interval based on drilled footages and lithology (Table 3-10). Each soil boring in the Rocky Flats Alluvium extended from ground surface to approximately three feet below the alluvium/bedrock contact. A three-foot (drilled footage) composite sample was collected at the surface of each borehole regardless of lithology. Six-foot composite samples were collected from three feet below ground surface to the alluvium/bedrock contact unless a lithologically distinct layer two feet or greater in thickness was encountered. A total of 70 samples (excluding field duplicates

TABLE 3-9

BACKGROUND BOREHOLE DATA FOR

ROCKY FLATS PLANT

Borehole Number	Borehole Status	Ground Surface Elev. (ft)	Total Depth (ft)	Bedrock Depth (ft)
B405189	5,6	6121.80	54.60	48.50
B400289	1,5	6105.90	52.00	49.60
B400389	1,5	6122.00	50.40	48.50
B400489	1,5	6105.90	56.00	54.00
B200589	1,5	5968.40	33.51	30.00
B200689	1,5	5960.10	35.70	30.60
B200789	1,5	5946.10	34.40	28.00
B200889	1,5	5936.10	27.80	22.80
B200989	2,5	5920.80	24.50	22.00
B201089	1,5	5883.10	19.55	7.50
B201189	1,5	5806.50	46.00	34.00
B201289	1,5	5826.10	32.10	23.40
B201489	1,5	5859.40	19.20	7.00
B201589	1,5	5846.00	20.30	8.20
B301889	1,5	5866.80	34.50	22.30
B401989	1,5	6025.60	33.00	20.50
B302089	1,5	5907.50	25.50	13.50
B402189	1,5	6024.60	49.00	7.50

KEY TO STATUS: 1 - Active Well; 2 - Abandoned Borehole; 3 - Abandoned Well;
4 - Inactive Well; 5 - Borehole Sampled; 6 - Observation Well

and redrills) collected from within the Rocky Flats Alluvium were submitted to the laboratory for chemical analysis.

Sampling methodology at locations originating in colluvium was the same as the sampling scheme used for the Rocky Flats Alluvium Boreholes except that these borings extended approximately twelve feet into bedrock so that weathered bedrock soil samples could be obtained. A total of 28 soil samples from the colluvial materials were collected and submitted for chemical analysis.

The weathered bedrock samples were comprised of two six-foot composite samples originating at the colluvium/bedrock contact. As in alluvial samples, discrete samples were collected if a lithologically distinct layer two feet or greater in thickness was encountered. Twenty bedrock soil samples were collected for chemical analysis.

Samples were submitted to the laboratory for chemical analysis. Soil samples were analyzed for the parameters listed in Table 3-10. With the exception of Target Compound List (TCL) organics, and hexavalent and trivalent chromium, this list includes all parameters for which investigative samples from the 881 Hillside, 903 Pad, Mound, East Trenches, Solar Evaporation Ponds, and West Spray Field have been analyzed. TCL organics were not expected to be present in background soils; therefore, they were not selected as analytes. A separate off-site investigation is being conducted to verify the background concentration range of plutonium in surficial soils.

TABLE 3-10

BACKGROUND BOREHOLE SAMPLE INFORMATION

BOREHOLE NUMBER	SAMPLE INFORMATION SAMPLE NUMBER	SAMPLE DATE	DEPTH INCREMENT(ft.)	LITHOLOGICAL DESCRIPTION
B405189	BH01890003	03/09/89	0.00 - 3.00	CLAYEY GRAVEL
B405189	BH01890309	03/09/89	3.60 - 8.55	SANDY GRAVEL
B405189	BH01890915	03/09/89	9.60 - 15.40	GRAVELLY CLAYEY SAND
B405189	BH01891521	03/09/89	15.60 - 20.30	SANDY GRAVELLY CLAY
B405189	BH01892127	03/09/89	21.60 - 26.50	GRAVEL
B405189	BH01893036	03/10/89	29.50 - 35.60	CLAYEY GRAVEL
B405189	BH01893638	03/10/89	35.60 - 37.60	GRAVELLY CLAY
B405189	BH01893844	03/10/89	37.60 - 42.60	GRAVELLY CLAYEY SAND
B405189	BH01894448	03/10/89	43.60 - 47.50	GRAVELLY CLAYEY SAND
B400289	BH02890003	04/12/89	0.00 - 3.00	SILTY CLAYEY SAND&GRAVEL
B400289	BH02890309	04/12/89	4.00 - 9.00	SILTY CLAYEY SAND&GRAVEL
B400289	BH02890915	04/12/89	9.00 - 14.90	SILTY CLAYEY SAND&GRAVEL
B400289	BH02891521	04/13/89	16.00 - 21.10	SILTY CLAYEY SAND&GRAVEL
B400289	BH02891521D	04/13/89	16.00 - 21.10	SILTY CLAYEY SAND&GRAVEL
B400289	BH02892130	04/13/89	21.10 - 28.70	SILTY CLAYEY SAND&GRAVEL
B400289	BH02893036	04/14/89	30.00 - 36.00	SILTY CLAYEY SAND&GRAVEL
B400289	BH02893642	04/14/89	36.00 - 41.30	SILTY CLAYEY SAND&GRAVEL
B400289	BH02894248	04/17/89	42.00 - 47.20	SILTY CLAYEY SAND&GRAVEL
B400389	BH03890003	04/25/89	0.00 - 3.00	SILTY SAND
B400389	BH03890309	04/25/89	3.00 - 9.00	SILTY SAND TO CLAYEY SAND
B400389	BH03890309D	04/25/89	3.00 - 9.00	SILTY SAND TO CLAYEY SAND
B400389	BH03890915	04/25/89	9.00 - 15.00	SILTY SAND
B400389	BH03891521	04/25/89	15.00 - 21.00	SILTY SAND
B400389	BH03892127	04/25/89	21.00 - 27.00	SILTY SAND
B400389	BH03892733	04/05/89	27.00 - 33.00	SILTY SAND
B400389	BH03893339	04/25/89	33.00 - 39.00	SILTY SAND
B400389	BH03893945	04/26/89	39.00 - 45.00	SILTY-CLAYEY SAND
B400389	BH03894548	04/26/89	45.00 - 48.50	SILTY-CLAYEY SAND
B400489	BH04890003	04/28/89	0.00 - 3.00	SILTY SAND
B400489	BH04890309	04/28/89	3.00 - 9.00	SILTY SAND
B400489	BH04890915	04/28/89	9.00 - 15.00	SAND & GRAVEL
B400489	BH04890915D	04/28/89	9.00 - 15.00	SAND & GRAVEL
B400489	BH04891521	04/28/89	15.00 - 21.00	SAND & GRAVEL
B400489	BH04892127	04/28/89	21.00 - 27.00	SAND&GRAVEL TO SILTY SAND
B400489	BH04892733	05/01/89	27.00 - 33.00	SILTY SAND
B400489	BH04893335	05/01/89	33.00 - 35.50	SILTY SAND
B400489	BH04893538	05/01/89	35.50 - 38.00	CLAYEY SILT
B400489	BH04893840	05/01/89	38.00 - 40.00	CLAYEY SILT AND SAND
B400489	BH04894046	05/01/89	40.00 - 46.00	SANDY GRAVEL
B400489	BH04894652	05/01/89	46.00 - 52.00	SANDY GRAVEL
B400489	BH04895254	05/01/89	52.00 - 54.00	SANDY GRAVEL
B200589	BH05890003R	03/08/89	0.00 - 2.80	SILTY SANDY CLAY
B200589	BH05890003	02/22/89	0.00 - 3.10	GRAVEL

*FB: Field Blank

TABLE 3-10
(Continued)

BACKGROUND BOREHOLE SAMPLE INFORMATION

BOREHOLE NUMBER	SAMPLE INFORMATION SAMPLE NUMBER	SAMPLE DATE	DEPTH INCREMENT(ft.)	LITHOLOGICAL DESCRIPTION
B200589	BH05890308	02/22/89	3.50 - 8.40	CLAY & SAND
B200589	BH05890308D	02/22/89	3.50 - 8.40	CLAY & SAND
B200589	BH05890913	02/22/89	9.50 - 12.70	CLAYEY SAND
B200589	BH05891317	02/22/89	13.50 - 17.00	SANDY CLAY
B200589	BH05891723	02/22/89	17.00 - 23.50	GRAVEL & SAND
B200589	BH05892325	02/22/89	23.50 - 25.50	GRAVEL & SAND
B200589	BH05892530	02/23/89	25.00 - 30.00	GRAVEL & SAND
B200689	BH06890003	03/09/89	0.00 - 1.90	SILT & CLAY
B200689	BH06890104	02/28/89	1.00 - 4.50	GRAVELLY CLAY
B200689	BH06890410	02/28/89	4.50 - 9.20	GRAVEL
B200689	BH06891016	02/28/89	9.90 - 15.90	SANDY GRAVEL
B200689	BH06891618	02/28/89	15.90 - 17.90	CLAY
B200689	BH06891824	02/28/89	17.90 - 23.90	SANDY CLAYEY GRAVEL
B200689	BH06892430	02/28/89	23.90 - 29.40	SAND & GRAVEL
B200789	BH07890003	03/08/89	0.00 - 2.90	SILTY SANDY CLAY
B200789	BH07890103	03/01/89	1.00 - 2.70	GRAVELLY CLAY
B200789	BH07890306	03/01/89	3.00 - 6.30	CALICHE
B200789	BH07890612	03/01/89	6.30 - 10.30	SAND & GRAVEL
B200789	BH07891218	03/01/89	12.00 - 17.70	GRAVELLY SAND CLAY
B200789	BH07891824	03/01/89	18.00 - 23.00	GRAVEL & SAND
B200789	BH07892426	03/01/89	24.00 - 26.00	GRAVEL & SAND
B200889	BH08890003	03/08/89	0.00 - 2.10	GRAVELLY CLAY
B200889	BH08890106	03/06/89	1.00 - 6.10	SANDY SILT CLAY
B200889	BH08890106D	03/06/89	1.00 - 6.10	SANDY SILTY CLAY
B200889	BH08890608	03/06/89	6.30 - 7.10	SILTY SAND & GRAVEL
B200889	BH08890814	03/06/89	8.30 - 13.70	SILTY SAND
B200889	BH08891420	03/06/89	14.30 - 19.30	SILTY SAND & GRAVEL
B200889	BH08892022	03/06/89	20.30 - 21.20	SILTY SAND & GRAVEL
B200989	BH09890003	03/08/89	0.00 - 2.80	GRAVEL
B200989	BH09890104	03/02/89	1.00 - 4.00	GRAVELLY CLAY
B200989	BH09890410D	03/02/89	4.00 - 9.90	GRAVEL & SAND
B200989	BH09890410	03/02/89	4.00 - 9.90	GRAVEL & SAND
B200989	BH09891016	03/02/89	10.00 - 14.80	GRAVEL & SAND
B200989	BH09891620	03/02/89	16.00 - 18.40	GRAVEL & SAND
B201089	BH10890003	03/09/89	0.00 - 2.60	SILTY SANDY CLAY
B201089	BH10890106D	03/02/89	1.00 - 6.50	SILTY CLAY
B201089	BH10890106	03/02/89	1.00 - 6.50	SILTY CLAY
B201189	BH11890003	03/17/89	0.00 - 3.00	CLAY
B201189	BH11890309	03/17/89	3.00 - 9.00	CLAY
B201189	BH11890915	03/17/89	9.00 - 15.00	CLAY
B201189	BH11890915D	03/17/89	9.00 - 15.00	CLAY

*FB: Field Blank

TABLE 3-10
(Continued)

BACKGROUND BOREHOLE SAMPLE INFORMATION

BOREHOLE NUMBER	SAMPLE INFORMATION SAMPLE NUMBER	SAMPLE DATE	DEPTH INCREMENT(ft.)	LITHOLOGICAL DESCRIPTION
B201189	BH11891521	03/17/89	15.00 - 21.00	CLAY
B201189	BH11892127	03/17/89	21.00 - 27.00	CLAY
B201189	BH11892733	03/17/89	27.00 - 33.00	CLAY
B201289	BH12890003	03/22/89	0.00 - 3.00	CLAY
B201289	BH12890307	03/22/89	3.00 - 6.80	SILTY CLAY
B201289	BH12890915	03/23/89	9.00 - 15.00	SILTY CLAY
B201289	BH12891521	03/23/89	15.00 - 20.65	SILTY CLAY
B201289	BH12891521D	03/23/89	15.00 - 20.65	SILTY CLAY
B201489	BH13890003	03/10/89	0.00 - 3.00	SILTY CLAY
B201489	BH13890307	03/10/89	3.00 - 7.00	SILTY CLAY
B201589	BH14890003	03/15/89	0.00 - 3.00	SILTY CLAY
B201589	BH14890307	03/15/89	3.00 - 7.00	SILTY CLAY
B301889	BH15890003	03/07/89	0.00 - 3.00	SILTY CLAY
B301889	BH15890309	03/07/89	3.00 - 9.00	SILTY CLAY
B301889	BH15890915	03/07/89	9.00 - 15.00	SILTY CLAY
B301889	BH15891521	03/07/89	15.00 - 21.00	SILTY CLAY
B401989	BH16890003	04/05/89	0.00 - 3.00	CLAY & GRAVEL
B401989	BH16890309	04/05/89	3.00 - 9.00	CLAY
B401989	BH16890915	04/05/89	9.20 - 13.30	CLAY
B401989	BH16891519	04/05/89	16.00 - 19.00	SANDY GRAVELLY CLAY
B302089	BH17890003	03/28/89	0.00 - 2.10	CLAY
B302089	BH17890306	03/28/89	3.60 - 6.00	CLAY
B402189	BH18890003	03/29/89	0.00 - 0.80	CLAY
B402189	BH18890307	03/29/89	3.30 - 7.30	CLAY
B201089	BH10890713	03/02/89	7.50 - 13.50	SILTY CLAYSTONE
B201089	BH10891319	03/02/89	13.50 - 19.50	SILTY CLAYSTONE
B201189	BH11893541	03/23/89	34.50 - 41.00	CLAYSTONE
B201189	BH11894146	03/23/89	41.00 - 46.00	CLAYSTONE
B201289	BH12892329	03/23/89	23.40 - 29.40	CLAYSTONE
B201289	BH12892930	03/23/89	29.00 - 29.90	CLAYSTONE
B201489	BH13891015	03/10/89	10.70 - 15.00	CLAYSTONE
B201489	BH13891015D	03/10/89	10.70 - 15.00	CLAYSTONE
B201489	BH13891519	03/10/89	15.00 - 19.20	CLAYSTONE
B201589	BH14890814	03/16/89	8.20 - 14.20	CLAYSTONE
B201589	BH14891417	03/16/89	14.20 - 17.00	SILTY CLAYSTONE

*FB: Field Blank

TABLE 3-10
(Continued)

BACKGROUND BOREHOLE SAMPLE INFORMATION

	SAMPLE INFORMATION			
BOREHOLE NUMBER	SAMPLE NUMBER	SAMPLE DATE	DEPTH INCREMENT(ft.)	LITHOLOGICAL DESCRIPTION
B301889	BH15892228	03/07/89	22.00 - 28.30	SANDY SILTY CLAYSTONE
B301889	BH15892834	03/07/89	28.30 - 34.30	SANDY SILTY CLAYSTONE
B401989	BH16892127	04/05/89	20.50 - 26.50	CLAYSTONE
B401989	BH16892733	04/05/89	26.50 - 32.50	CLAYSTONE
B302089	BH17891319	03/28/89	13.50 - 19.50	CLAYSTONE
B302089	BH17891319D	03/28/89	13.50 - 19.50	CLAYSTONE
B302089	BH17891925	03/28/89	19.50 - 25.50	CLAYSTONE
B402189	BH18890713	03/29/89	7.50 - 13.50	CLAYSTONE
FB	BH08890306FB	03/06/89	N/A	FIELD BLANK
FB	BH05890222FB	02/22/89	N/A	FIELD BLANK
FB	BH11890317FB	03/17/89	N/A	FIELD BLANK
FB	BH12890323FB	03/23/89	N/A	FIELD BLANK
FB	BH06890003FB	03/08/89	N/A	FIELD BLANK
FB	BH17890328FB	03/28/89	N/A	FIELD BLANK
FB	BH02890915FB	04/12/89	N/A	FIELD BLANK
FB	BH03893339FB	04/25/89	N/A	FIELD BLANK
FB	BH04892127FB	04/28/89	N/A	FIELD BLANK
FB	BH15890307FB	03/07/89	N/A	FIELD BLANK
B201289	BH12893032	03/23/89	29.90 - 32.00	SANDY SILTSTONE
B201489	BH13890709	03/10/89	7.00 - 9.30	SILTY SANDSTONE
B201589	BH14891720	03/16/89	17.00 - 20.00	CLAYEY SANDSTONE
B402189	BH18891319	03/29/89	13.50 - 19.50	SANDSTONE

*FB: Field Blank

TABLE 3-11

BACKGROUND BOREHOLE SAMPLING PARAMETERS

METALS

CLP Inorganic Target Analyte List
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc

Other Metals
- Cesium
- Lithium
- Molybdenum
- Strontium
- Tin

RADIONUCLIDES

Gross Alpha
Gross Beta
Strontium 90
Cesium 137
Radium 226, 228
Uranium 233 + 234, 235 and 238
Americium 241
Plutonium 239 + 240
Tritium

OTHER

pH
Nitrate
Sulfide
Cyanide

SECTION 4.0

BACKGROUND CHEMICAL CHARACTERIZATION

Background data for ground water, surface water, sediment, and boreholes were evaluated to establish background conditions in each media. Chemical results and a discussion of general geochemical characteristics of each media sampled are summarized in the following sections. This evaluation is based on data received as of December 15, 1989 and includes results obtained from one round of ground water, two rounds of surface water, and one round of borehole and sediment sampling. Approximately 90% of the data has been received and are incorporated in this project. Missing data are identified in Appendix A.

Data validation has not yet been completed. Tolerance intervals will be recalculated upon receipt on complete validation packages and the currently outstanding data.

4.1 <u>GROUND WATER</u>

A two system model of ground-water flow (Section 3.1) is substantiated by the analytical results from background ground-water samples (Figure 4-1). Plate 2 presents Stiff diagrams for the Round 1, 1989 samples of ground water and surface water at various sampling locations. Relatively high sodium, chloride, and high sulfate distinguishes the unweathered sandstone ground water from other ground-water subgroups. Stiff diagrams for the surficial ground-water flow system are similar in shape and general magnitude. Closer inspection of the Stiff diagrams suggests that the ground water of the Rocky Flats Alluvium is less saline than any of the subgroups it recharges. With the exception of the weathered sandstone this is confirmed in a comparison of the mean recorded total dissolved solids (TDS) for each subgroup as shown in Table 4-1. This phenomenon is likely a result of increases in clay content, the relatively greater evaporative losses in the colluvium and valley fill (less saturated thickness than the Rocky Flats Alluvium), and in the case of the weathered and unweathered bedrock, longer contact time with these materials (less permeable than the Rocky

FIGURE 4-1

TRILINEAR DIAGRAM

GROUND WATER - ROUND 1, 1989

HC–GRAM

HydroChemical Graphic Representation Analysis Methods

Version: HC-GRAM 1.42

PROJECT: Ground Water - Round 1
plus - Rocky Flats Alluvial Ground Water
circle - Colluvial Ground Water
diamond - Valley Fill Alluvial Ground Water
X - Weathered Bedrock Ground Water
square - Unweathered Sandstone

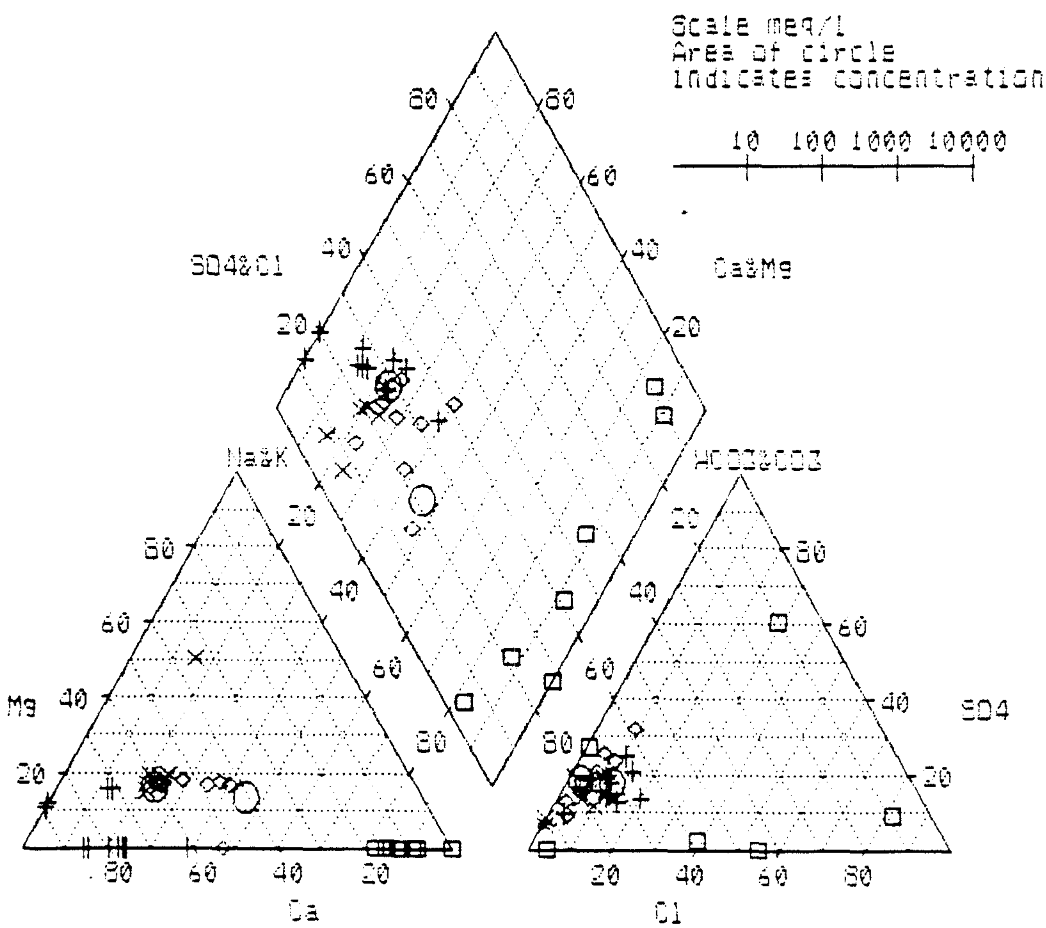


TABLE 4-1

COMPARISON OF TDS FOR GROUND-WATER SUBGROUPS

SUBGROUP	MEAN TDS (mg/l)	REFERENCED TABLE
Rocky Flats Alluvium	217	3-5
Colluvium	405	3-8
Valley Fill	416	3-11
Weathered Bedrock		
Weathered Claystone	255	3-15
Weathered Sandstone	195	3-18
Unweathered Sandstone	1761	3-21

Note: See Referenced Table for details

Flats Alluvium). In addition, the claystone is less chemically inert than the constituents in the Rocky Flats Alluvium.

4.1.1 Rocky Flats Alluvium Ground Water

Rocky Flats Alluvium ground water is relatively low in Total Dissolved Solids (TDS), major ions, and uranium. Several trace metals (iron, molybdenum, nickel, potassium, strontium, zinc, and cyanide) were also detected. Statistical summaries of chemical results are presented in Tables 4-3, 4-4, and 4-5. As discussed in Section 3.1.1, a well cluster was installed to evaluate geochemical stratification within alluvial ground water. Chemical results for this well cluster are presented in Table 4-2. Total dissolved and total suspended solids are greater in the well completed at the water table, (B405689) than in the well completed at the base of the Rocky Flats Alluvium (B405789). Near the water table the ground water is relatively enriched in calcium carbonate and relatively depleted in sodium chloride. Complete characterization of the chemical stratification of ground water in Rocky Flats Alluvium requires additional data both to characterize chemical stratification through time and to establish the reproducibility of these results.

4.1.2 Colluvial Ground Water

Ten wells were installed to monitor ground water within colluvium, although eight of those wells were dry during Round 1, 1989 sampling. Although tolerance intervals cannot be compiled with so few data, dry wells will provide valuable information about the extent of unsaturated materials.

Statistical summaries of chemical results are presented in Tables 4-6, 4-7, and 4-8. In the absence of additional data, statistical comparisons of background colluvial ground water to non-background ground water is not possible.

TABLE 4-2

CHEMICAL STRATIFICATION IN ROCKY FLATS ALLUVIUM GROUND WATER

	UNITS	B400489	B405689	B405789
Screened Interval: (ft)		9.87-54.45	3.0-22.51	43.01-52.48
Analyte				
Calcium (Ca)	mg/l	47	64.5	30.9
Magnesium (Mg)	mg/l	5U	5.32	5U
Manganese (Mn)	mg/l	.268	.139	.0150U
Sodium (Na)	mg/l	8.90	5U	9.02
Total Suspended Solids (TSS)	mg/l	18	120	12
Total Dissolved Solids (TDS)	mg/l	220	250	180
Chloride (Cl)	mg/l	11	4	14
Nitrate-Nitrite as N (N)	mg/l	0.92	0.66	1.2
Sulfate (SO_4)	mg/l	22	32	16
HCO_3 as ($CaCO_3$)	mg/l	150	200	100
pH		7.9	7.9	7.2
Gross Alpha	pCi/l	2±2	3±3	1±2
Gross Beta	pCi/l	-1±2	1±2	2±2
Uranium 233, 234	pCi/l	0.6±0.2	1.3±0.3	0.0±0.1
Uranium 235	pCi/l	0.0±0.1	0.0±0.1	0.0±0.1
Uranium 238	pCi/l	0.3±0.1	1.1±0.3	0.0±0.1
Strontium 89, 90	pCi/l	0.1±0.4	0.1±0.4	-0.1±0.4
Plutonium 239, 240	pCi/l	0.00±0.1	0.0±0.1	0.00±0.01
Americium 241	pCi/l	0.00±0.1	0.00±0.01	0.00±0.01
Cesium 137	pCi/l	0.0±0.5	0.3±0.5	0.3±0.6
Tritium	pCi/l	30±210	190±210	80±150

Note: Analytes not listed in this table were not detected or not reported for all three wells.

TABLE 4-3

BACKGROUND DISSOLVED METAL RESULTS

ROCKY FLATS ALLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	Calcium	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Strontium	Zinc
NUMBER OF SAMPLES	11	11	11	11	11	11	11	11	11	11
NUMBER OF DETECTS	11	2	4	10	1	1	1	9	3	4
PERCENT DETECTS	100	18	36	91	9	9	9	82	27	36
MAXIMUM DETECTED VALUE	71.4	.266	5.79	.268	.0136	.0432	7.73	11	.159	.141
MINIMUM DETECTED VALUE	18.6	.129	5.23	.0187	.0136	.0432	7.73	6.89	.115	.0289
*MEAN	38	---	---	.09	---	---	---	7.55	---	---
*STANDARD DEVIATION	16.8	---	---	.1	---	---	---	2.07	---	---
*COEFFICIENT OF VARIATION	.442	---	---	1.111***	---	---	---	.274	---	---
MINIMUM REPORTED DETECTION LIMIT	---	.1	5	.015	.1	.04	5	5	.1	.02
MAXIMUM REPORTED DETECTION LIMIT	---	.1	5	.015	.1	.04	5	5	1	.02
APPROPRIATE STATISTICAL METHOD	TIN	TP	TP	TIN	TIP	TIP	TIP	TIN	TP	TP
*TOLERANCE INTERVAL (UPPER LIMIT)	85	---	---	.365	---	---	---	13.4	---	---
MEAN + 3 STD. DEVIATION	88.4	---	---	0.39	---	---	---	13.76	---	---
ARAR VALUE	NS	0.3	NS	0.05	0.1	0.2	NS	NS	NS	2.0

Notes: Dissolved Metals not detected in Rocky Flats Alluvium: Al,Sb,As,Ba,Be,Cd,Cs,Cr,Co,Cu,Pb,Li,Hg,Se,Ag,Tl,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-4

OTHER BACKGROUND INORGANIC RESULTS

ROCKY FLATS ALLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CHLORIDE	CYANIDE	NITRATE AS N	PH	SULFATE	BICARBONATE	TDS
NUMBER OF SAMPLES	11	11	11	11	11	11	11
NUMBER OF DETECTS	11	2	11	11	11	11	11
PERCENT DETECTS	100	18	100	100	100	100	100
MAXIMUM DETECTED VALUE	14	.0038	2.3	7.9	39	450	300
MINIMUM DETECTED VALUE	3	.0035	0.66	6.6	10	72	150
*MEAN	6.3	---	1.4	7.3	22.3	144	217
*STANDARD DEVIATION	3.3	---	0.56	0.4	8.1	104	48
*COEFFICIENT OF VARIATION	.524	---	.4	.055	.363	.722	.221
MINIMUM REPORTED DETECTION LIMIT	---	.0025	---	---	---	---	---
MAXIMUM REPORTED DETECTION LIMIT	---	.0025	---	---	---	---	---
APPROPRIATE STATISTICAL METHOD	TIN	TP	TIN	TIN	TIN	TIN	TIN
*TOLERANCE INTERVAL (UPPER LIMIT)	15.6	---	2.98	8.6	45.1	436	352
**TOLERANCE INTERVAL (LOWER LIMIT)	---	---	---	5.98	---	---	---
MEAN + 3 STD. DEVIATION	16.2	---	3.08	8.5	46.6	453	361
MEAN - 3 STD. DEVIATION	---	---	---	6.1	---	---	---

Notes: Ions not detected in Rocky Flats Alluvium: Carbonate

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-5

BACKGROUND DISSOLVED RADIOCHEMICAL RESULTS

ROCKY FLATS ALLUVIUM GROUND WATER

(ROUND 1, 1989) (CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	11	11	11	11	11	11	11	11	11	11	3
MAX. VALUE	12+/-8	13+/-3	1.3+/-.3	0+/-.1	1.1+/-.3	.1+/-.5	.01+/-.01	0+/-.01	.3+/-.6	250+/-220	.5+/-.5
MIN. VALUE	0+/-1	-1+/-2	0+/-.1	0+/-.1	0+/-.1	-.7+/-1	0+/-.01	0+/-.01	-.3+/-.7	30+/-210	.1+/-.5
*MEAN	3.182	3.545	0.418	0.000	0.282	-0.064	0.001	0.000	0.036	140.909	0.333
*STD. DEVIATION	3.325	3.917	0.437	0.000	0.324	0.2186	0.0029	0.000	0.2012	59.765	0.5703
COEFF./VARIATION	1.045***	1.105***	1.044***	0.000	1.150***	-3.416***	2.9***	0.000	5.589***	0.424	1.713***
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	ANOVA
*T.INTERVAL(U.LIMIT)	12.543	14.570	1.647	0.000	0.195	0.552	0.009	0.000	0.603	309.149	---
MEAN • 3 STD. DEV.	13.158	15.295	1.728	0.000	1.255	0.592	0.010	0.000	0.640	320.205	2.044

Notes: Because of results on other radionuclides, Radium 228 was not run on Background Rocky Flats Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - *Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.*

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-6

BACKGROUND DISSOLVED METAL RESULTS

COLLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	Calcium	Magnesium	Manganese	Lithium	Sodium
NUMBER OF SAMPLES	2	2	2	2	2
NUMBER OF DETECTS	2	2	1	1	2
PERCENT DETECTS	100	100	50	50	100
MAXIMUM DETECTED VALUE	76.8	15.3	.088	.172	98.7
MINIMUM DETECTED VALUE	65.6	10.6	.088	.172	28.1
*MEAN	71.2	12.95	.03	.04	63.4
*STANDARD DEVIATION	5.6	2.35	.0668	.15	35.3
*COEFFICIENT OF VARIATION	.0786	.1815	2.227***	3.75	.5568
MINIMUM REPORTED DETECTION LIMIT	---	---	.015	.01	---
MAXIMUM REPORTED DETECTION LIMIT	---	---	.015	.01	---
APPROPRIATE STATISTICAL METHOD	NONE	NONE	TP	TP	NONE
*TOLERANCE INTERVAL (UPPER LIMIT)	---	---	---	---	---
MEAN • 3 STD. DEVIATION	88.0	20.0	.230	.49	169
ARAR VALUE	NS	NS	0.05	2.5	NS

Notes: Dissolved Metals not detected in Colluvium: Al,Sb,As,Ba,Be,Cd,Cs,Cr,Co,Cu,Fe,Pb,Hg,Mo,Ni,Se,Sr,K,Ag,Tl,Sn,V,Zn

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-7

OTHER BACKGROUND INORGANIC RESULTS

COLLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/1)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS
NUMBER OF SAMPLES	2	2	2	2	2	2
NUMBER OF DETECTS	2	1	2	2	2	2
PERCENT DETECTS	100	50	100	100	100	100
MAXIMUM DETECTED VALUE	20	.18	7.4	86	470	520
MINIMUM DETECTED VALUE	11	.18	7.1	45	230	290
*MEAN	15.5	0.07	7.25	65.5	350	405
*STANDARD DEVIATION	4.5	0.12	0.15	20.5	120	115
*COEFFICIENT OF VARIATION	.2903	1.7***	.0207	.3129	.3429	.2839
MINIMUM REPORTED DETECTION LIMIT	---	.05	---	---	---	---
MAXIMUM REPORTED DETECTION LIMIT	---	.05	---	---	---	---
APPROPRIATE STATISTICAL METHOD	NONE	TP	NONE	NONE	NONE	NONE
*TOLERANCE INTERVAL (UPPER LIMIT)	---	---	---	---	---	---
**TOLERANCE INTERVAL (LOWER LIMIT)	---	---	---	---	---	---
MEAN + 3 STD. DEVIATION	29.0	.43	7.7	127	710	750
MEAN - 3 STD. DEVIATION	---	---	6.8	---	---	---

Notes: Ions not detected in Colluvium: Carbonate, Cyanide

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-8

BACKGROUND RADIOCHEMICAL RESULTS

COLLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	2	2	2	2	2	2	2	2	2	2	1
MAX. VALUE	27+/-12	12+/-5	11+/-1	.3+/-.1	7.7+/-.7	.1+/-.4	0+/-.01	0+/-.01	.2+/-.6	100+/-150	.4+/-.2
MIN. VALUE	1+/-3	2+/-2	.6+/-.2	0+/-.1	.4+/-.2	0+/-.5	0+/-.01	-.01+/-.01	-.6+/-.6	-100+/-140	.4+/-.2
*MEAN	14.000	7.000	5.800	0.150	4.050	0.050	0.000	-0.005	-0.200	0.000	---
*STD. DEVIATION	30.871	14.866	12.712	0.335	8.884	0.112	0.000	0.0112	0.566	100.0	---
COEFF./VARIATION	2.205***	2.124***	2.192***	2.233***	2.194***	2.240***	0.000	-2.240***	-2.83***	0.000	---
APP. STAT. METHOD	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
*T.INTERVAL(U.LIMIT)	----	---	---	---	---	---	---	---	---	---	---
MEAN + 3 STD. DEV.	106.61	51.598	43.94	1.155	30.702	0.386	---	0.029	14.98	300	---

Notes: Because of results on other radionuclides, Radium 228 was not run on Background Colluvium Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lower Tolerance Intervals reported for two-sided parameters.*

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

A comparison of the summary tables for colluvial ground water to that of Rocky Flats Alluvium ground water indicates that ground water in colluvium is relatively high in all the major ions as well as uranium, and relatively low in nitrate. In addition, iron, molybdenum, nickel, potassium, strontium, zinc, and cyanide were detected in alluvial ground water and were not detected in colluvial water, while lithium was only detected in colluvial ground water. The absence of detected analytes with colluvial ground water may be in part an artifact of the small sample size.

4.1.3 Valley Fill Ground Water

Statistical summaries of chemical results are presented in Tables 4-9, 4-10, and 4-11. Nineteen tolerance intervals based on a normal distribution are presented. Of these, four analytes, all radionuclides, have a coefficient of variation in excess of one or less than zero which suggests recalculation as lognormal tolerance intervals may be appropriate.

Valley fill ground water is chemically similar to the colluvium. Both ground waters have similar concentrations of major ions, uranium, and nitrate which differentiate these waters from the Rocky Flats Alluvium ground water. The uranium concentrations are somewhat less than the colluvial ground water but are higher than the Rocky Flats Alluvium ground water. However, like the ground water of the Rocky Flats Alluvium, several trace metals were detected that were not detected in the colluvium (iron, molybdenum, nickel, strontium, and zinc). Also detected in the valley fill ground water was selenium, mercury, and lithium. Lithium was the one trace metal, aside from manganese, also detected in the colluvium.

As detailed in Section 3.1.3 both the Rock Creek drainage and the Woman Creek drainage have been sampled to ensure evaluation of spatial variability. Table 4-12 presents concentration ranges of analytes for each drainage system. Woman Creek valley fill ground water is higher in concentration for most of the analytes listed relative to the Rock Creek

TABLE 4-9

BACKGROUND DISSOLVED METAL RESULTS

VALLEY FILL ALLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS IN mg/l)

	CALCIUM	IRON	MERCURY	LITHIUM	MAGNESIUM	MANGANESE	SODIUM	SELENIUM	ZINC
NUMBER OF SAMPLES	8	8	8	8	8	8	8	8	8
NUMBER OF DETECTS	8	1	2	7	7	4	8	1	1
PERCENT DETECTS	100	13	25	88	88	50	100	13	13
MAXIMUM DETECTED VALUE	103	.944	.0003	.0223	18.10	.686	74.7	.0114	.0212
MINIMUM DETECTED VALUE	18.9	.944	.0003	.0116	8.5	.0546	19.3	.0114	.0212
*MEAN	56.94	---	---	0.01	10.83	--- **	37.88	---	---
*STANDARD DEVIATION	25.46	---	---	.0041	4.94	---	15.72	---	---
*COEFFICIENT OF VARIATION	.4471	---	---	.41	.4561	---	.4150	---	---
MINIMUM REPORTED DETECTION LIMIT	---	.1	.0002	.010	5	.015	---	.005	.020
MAXIMUM REPORTED DETECTION LIMIT	---	.1	.0002	.010	5	.015	---	.005	.020
APPROPRIATE STATISTICAL METHOD	TIN	TP	TP	TIN	TIN	ANOVA	TIN	TP	TP
*TOLERANCE INTERVAL (UPPER LIMIT)	138	---	---	.028	26.57	---	88	---	---
MEAN + 3 STD. DEVIATION	133.3	---	---	.022	25.65	---	85.04	---	---
ARAR VALUE	NS	0.3	0.002	2.5	NS	0.05	NS	0.01	2.0

Notes: Dissolved Metals not detected in Valley Fill Alluvium: Al,Sb,As,Ba,Be,Cd,Cs,Cr,Co,Cu,Pb,Mo,Ni,K,Ag,Sr,Tl,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Manganese mean determined by Cohens method is less than zero. Will evaluate with lognormal values for final.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-10

OTHER BACKGROUND INORGANIC RESULTS

VALLEY FILL ALLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS
NUMBER OF SAMPLES	8	8	8	8	8	8
NUMBER OF DETECTS	7	3	8	8	8	8
PERCENT DETECTS	88	38	100	100	100	100
MAXIMUM DETECTED VALUE	26	.69	8.0	120	610	800
MINIMUM DETECTED VALUE	6	.05	6.8	13	110	200
*MEAN	12.22	---	7.4	56.5	269	416
*STANDARD DEVIATION	8.81	---	0.34	29.35	141	166
*COEFFICIENT OF VARIATION	.7209	---	.0459	.5195	.524	.399
MINIMUM REPORTED DETECTION LIMIT	3	.05	---	---	---	---
MAXIMUM REPORTED DETECTION LIMIT	3	.05	---	---	---	---
APPROPRIATE STATISTICAL METHOD	TIN	TP	TIN	TIN	TIN	TIN
*TOLERANCE INTERVAL (UPPER LIMIT)	40.29	---	8.68	150	719	947
**TOLERANCE INTERVAL (LOWER LIMIT)	---	---	6.12	---	---	---
MEAN + 3 STD. DEVIATION	38.65	---	8.42	145	692	947
MEAN - 3 STD. DEVIATION	---	---	6.38	---	---	---

Notes: Ions not detected in Colluvium: Carbonate, Cyanide

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-11

BACKGROUND RADIOCHEMICAL RESULTS

VALLEY FILL ALLUVIUM GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	8	8	8	8	8	8	8	8	8	8	2
MAX. VALUE	10+/-9	14+/-4	4.1+/-.6	.1+/-.1	2.8+/-.5	.5+/-.5	.01+/-.01	0+/-.01	.3+/-.6	380+/-150	.2+/-.2
MIN. VALUE	2+/-2	2+/-2	.4+/-.2	0+/-.1	.2+/-.2	-.3+/-.5	0+/-.01	-.01+/-.01	-.5+/-.8	50+/-150	-.1+/-.2
*MEAN	4.250	5.750	1.950	0.063	1.475	0.113	0.001	-0.004	0.012	151.250	0.050
*STD. DEVIATION	2.906	4.009	1.421	0.053	1.132	0.240	0.003	0.005	0.247	110.998	0.177
COEFF./VARIATION	0.684	0.697	0.729	0.844	0.768	2.126***	3.3***	-1.25***	20.6***	0.734	3.536***
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	NONE
*T.INTERVAL(U.LIMIT)	13.515	18.530	6.481	0.232	5.084	0.878	0.012	0.012	0.776	505.111	0.050
MEAN + 3 STD. DEV.	12.968	17.776	6.214	0.223	4.871	0.834	0.011	0.011	0.754	484.24	0.580

Notes: Because of results on other radionuclides, Radium 228 was not run on Background Valley Fill Alluvium Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-12

RANGES OF CHEMICAL RESULTS FOR VALLEY FILL ALLUVIAL GROUND WATER BY DRAINAGE SYSTEM

Parameter	Rock Creek Drainage* Range of concentrations (mg/l)	Woman Creek and Associated Drainage** Range of concentrations (mg/l)
Calcium	18.9 - 41.90	68.10 - 103
Iron	0.944	ND
Lithium	0.0116 - 0.0154	0.0126 - 0.0223
Magnesium	8.50 - 8.61	11.80 - 18.10
Manganese	0.0649 - 0.208	0.0546 - 0.686
Selenium	ND	0.0114
Sodium	19.30 - 34.70	31.40 - 74.70
Zinc	ND	0.0212
Total Dissolved Solids	200 - 800	360 - 470
Chloride	6 - 84	14 - 26
Nitrate	0.69	0.05 - 0.08
Sulfate	13 - 53	52 - 120
Bicarbonate	110 - 230	280 - 610
pH (pH units)	6.8 - 7.4	7.4 - 8.0
Gross Alpha	2±2 - 4±4	3±6 - 10±9
Gross Beta	2±2 - 6±3	5±3 - 14±4
Uranium 233, 234	0.4±0.2 - 1.4±0.3	2.2±0.3 - 4.1±0.6
Uranium 235	0.0±0.1 - 0.1±0.1	0.1±0.1 - 0.1±0.1
Uranium 238	0.8±0.2 - 1.2±0.3	1.4±0.3 - 2.8±0.5
Strontium 89, 90	-0.3±0.5 - 0.5±0.5	-0.1±0.5 - -0.3±0.5
Plutonium 239, 240	0.00±0.01 - 0.01±0.01	0.00±0.01 - 0.00±0.01
Americium 241	-0.01±0.01 - 0.00±0.01	-0.01±0.01 - 0.00±0.01
Cesium 137	-0.3±0.6 - 0.3±0.6	-0.05±0.08 - 0.1±0.6
Tritium	50±150 - 190±150	50±150 - 380±150
Radium 226	NR	-0.1±0.2 - 0.2±0.2

* Range of values for wells B102289, B102389, B202489, and B202589

** Range of values for wells B402689, B302789, B302889, and B302989. Well B303089 was dry during Round 1.

ND Not detected in any sample from the subgroup

NR Not reported; not analyzed

valley fill ground water. Therefore, the concentrations presented in the table indicate that two populations may be present.

4.1.4 Weathered Bedrock Ground Water

Weathered bedrock ground water is a mixture derived from claystone and sandstone. Statistical summaries of chemical results of weathered claystone ground water are presented in Tables 4-13, 4-14, and 4-15. Summaries of weathered sandstone ground water are found in Tables 4-16, 4-17, and 4-18. Comparison of Tables 4-13 through 4-15 to Tables 4-16 through 4-18, albeit recognizing the small sample size upon which these tables are based suggest the possibility that weathered claystone ground water and weathered sandstone ground water may be considered a single population. Unlike the valley fill and colluvial ground water which appear chemically similar to each other and different from the Rocky Flats Alluvial ground water, weathered claystone and weathered sandstone ground water appear to be chemically similar to each other and show characteristics of both the Rocky Flats Alluvium and colluvium/valley fill ground waters. Major cation concentrations are similar to the colluvium/valley fill ground waters; while major anion concentrations and TDS resemble the Rocky Flats Alluvial ground water. Many of the trace metals detected in either the Rocky Flats Alluvium, colluvium, and valley fill ground water, were detected in the weathered bedrock ground water. In addition, chromium and thallium were just above detection limits in the weathered bedrock ground water. A notable difference between the weathered sandstone and weathered claystone ground water is the uranium concentrations. Weathered claystone ground water has higher uranium concentrations (similar to the colluvial and valley fill ground waters) than the weathered sandstone ground water (similar to the Rocky Flats Alluvium ground water).

4.1.5 Unweathered Sandstone Ground Water

Statistical summaries of the chemical results of unweathered sandstone ground water are presented in Tables 4-19, 4-20 and 4-21. Nine tolerance intervals based upon the normal

TABLE 4-13

BACKGROUND DISSOLVED METALS RESULTS

WEATHERED CLAYSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CALCIUM	MERCURY	LITHIUM	MAGNESIUM	MANGANESE	MOLYBDENUM	SODIUM	THALLIUM	ZINC
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4
NUMBER OF DETECTS	4	1	2	4	3	2	4	1	2
PERCENT DETECTS	100	25	50	100	75	50	100	25	50
MAXIMUM DETECTED VALUE	73.4	.0008	.0381	45.3	.126	.015	36.9	.01	.107
MINIMUM DETECTED VALUE	41.4	.0008	.013	6.7	.053	.0113	15.7	.01	.059
*MEAN	51.9	---	.09	18.97	.06	.09	24.7	---	0.03
*STANDARD DEVIATION	13.03	---	.0699	15.58	.051	.0795	8.0	---	.064
*COEFFICIENT OF VARIATION	.2511	---	.7767	.8213	.85	.8833	.3239	---	2.133***
MAXIMUM REPORTED DETECTION LIMIT	---	.0002	.1	---	.015	.1	---	.05	.02
MINIMUM REPORTED DETECTION LIMIT	---	.0002	.1	---	.015	.1	---	.01	.02
APPROPRIATE STATISTICAL METHOD	ANOVA	TP	TP	ANOVA	ANOVA	TP	ANOVA	TP	TP
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	---	---	---	---	---	---	---
MEAN + 3 STD. DEVIATION	91.0	---	0.30	65.7	0.21	0.33	48.7	---	0.22
ARAR VALUE	NS	0.002	2.5	NS	0.05	0.1	NS	0.01 U	2.0

Notes: Dissolved Metals not detected in Weathered Claystone Ground Water: Al,Sb,As,Ba,Be,Cd,Cs,Cr,Co,Cu,Fe,Pb,Ni,K,Se,Ag,Sr,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-14

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED CLAYSTONE GROUND WATER (ROUND 1,1989)

(CONCENTRATIONS IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS	CYANIDE
NUMBER OF SAMPLES	4	4	4	4	4	4	4
NUMBER OF DETECTS	2	4	4	4	4	4	1
PERCENT DETECTS	50	100	100	100	100	100	25
MAXIMUM DETECTED VALUE	11	.58	8.2	44	400	320	.0036
MINIMUM DETECTED VALUE	6	.1	7.4	11	180	210	.0036
*MEAN	3.54	.325	7.675	26.75	260	255	---
*STANDARD DEVIATION	5.79	.19	.31	11.78	86.02	43.87	---
*COEFFICIENT OF VARIATION	1.6***	.5846	.0404	.4404	.3309	.1720	---
MINIMUM REPORTED DETECTION LIMIT	3	---	---	---	---	---	.0025
MAXIMUM REPORTED DETECTION LIMIT	3	---	---	---	---	---	.0025
APPROPRIATE STATISTICAL METHOD	TP	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	TP
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	---	---	---	---	---
**TOLERANCE INTERVAL(LOWER LIMIT)	---	---	5.69	---	---	---	---
MEAN + 3 STD. DEVIATION	20.9	0.895	8.605	62.09	518	387	---
MEAN - 3 STD. DEVIATION	---	---	6.745	---	---	---	---

Notes: Ions not detected in Colluvium: Carbonate

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >=

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-15

BACKGROUND RADIOCHEMICAL RESULTS

WEATHERED CLAYSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4	4	3
MAX. VALUE	12+/-4	7+/-2	5.8+/-.6	.2+/-.1	3.2+/-.5	.1+/-.5	.03+/-.02	0+/-.01	.4+/-.6	100+/-160	.6+/-.3
MIN. VALUE	0+/-3	3+/-3	.7+/-.2	0+/-.1	.4+/-.2	-.2+/-.4	0+/-.01	0+/-.01	-.1+/-.5	-100+/-230	.4+/-.5
MEAN	6.750	5.500	3.150	0.075	2.000	0.000	0.007	0.000	0.175	2.500	0.500
*STD. DEVIATION	9.4885	6.9011	4.2716	0.1237	2.6736	0.1225	0.0159	0.000	0.2789	88.4767	0.7681
COEFF./VARIATION	1.4***	1.3***	1.4***	1.6***	1.337	UNDETERM.	2.3***	UNDETERM.	1.6***	35.4***	1.5***
APP. STAT. METHOD	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA
*T.INTERVAL(U.LIMIT)	55.568	41.006	25.127	0.712	15.753	0.630	0.089	0.000	1.610	457.713	6.380
MEAN + 3 STD. DEV.	35.215	26.203	15.965	0.446	10.019	0.3675	.0547	0.000	1.012	268.740	2.804

Notes: Because of results on other radionuclides, Radium 228 was not run on Background Weathered Claystone Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-16

BACKGROUND DISSOLVED METALS RESULTS

WEATHERED SANDSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CALCIUM	CHROMIUM	LITHIUM	MAGNESIUM	MANGANESE	MOLYBDENUM	SODIUM
NUMBER OF SAMPLES	2	2	2	2	2	2	2
NUMBER OF DETECTS	2	1	1	2	2	1	2
PERCENT DETECTS	100	50	50	100	100	50	100
MAXIMUM DETECTED VALUE	65.7	.0122	.0106	9.41	.292	.015	25.6
MINIMUM DETECTED VALUE	36.2	.0122	.0106	6.05	.0178	.015	13.7
*MEAN	50.95	.01	.09	7.73	.155	.09	19.7
*STANDARD DEVIATION	14.75	.002	.082	1.68	.14	.078	5.95
*COEFFICIENT OF VARIATION	.2895	.2	.9111	.2173	.9032	.8667	.3020
MAXIMUM REPORTED DETECTION LIMIT	---	.01	.1	---	---	.1	---
MINIMUM REPORTED DETECTION LIMIT	---	.01	.1	---	---	.1	---
APPROPRIATE STATISTICAL METHOD	NONE	TP	TP	NONE	NONE	TP	NONE
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	---	---	---	---	---
MEAN + 3 STD. DEVIATION	95.2	.016	.34	12.8	.575	0.32	37.6
ARAR VALUE	NS	0.05	2.5	NS	0.05	0.1	NS

Notes: Dissolved Metals not detected in Weathered Sandstone Ground Water: Al,Sb,As,Ba,Be,Cd,Cs,Co,Cu,Fe,Pb,Hg,Ni,K,Se,Ag,Sr,Tl,Sn,V,Zn

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: *TIN - Tolerance Interval* based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-17

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED SANDSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS
NUMBER OF SAMPLES	2	2	2	2	2	2
NUMBER OF DETECTS	2	2	2	2	2	2
PERCENT DETECTS	100	100	100	100	100	100
MAXIMUM DETECTED VALUE	15	1.6	7.5	48	230	220
MINIMUM DETECTED VALUE	6	.18	7.2	16	140	170
*MEAN	10.5	.89	7.35	32	185	195
*STANDARD DEVIATION	4.5	.71	.15	16	45	25
*COEFFICIENT OF VARIATION	.4286	.7978	.0204	.5	.2432	.1282
MINIMUM REPORTED DETECTION LIMIT	---	---	---	---	---	---
MAXIMUM REPORTED DETECTION LIMIT	---	---	---	---	---	---
APPROPRIATE STATISTICAL METHOD	NONE	NONE	NONE	NONE	NONE	NONE
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	---	---	---	---
**TOLERANCE INTERVAL(LOWER LIMIT)	---	---	---	---	---	---
MEAN + 3 STD. DEVIATION	24.0	3.0	7.8	80	320	270
MEAN - 3 STD. DEVIATION	---	---	6.9	---	---	---

Notes: Ions not detected in Weathered Sandstone: Carbonate, Cyanide

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: *TIN - Tolerance Interval* based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-18

BACKGROUND DISSOLVED RADIOCHEMICAL RESULTS

WEATHERED SANDSTONE GROUND WATER

(ROUND 1, 1989) (CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	2	2	2	2	2	2	2	2	2	2	1
MAX. VALUE	7+/-5	2+/-3	1.1+/-.3	0+/-.1	.6+/-.2	-.1+/-.6	.01+/-.01	.01+/-.01	.3+/-.7	100+/-210	.4+/-1
MIN. VALUE	3+/-3	0+/-2	.3+/-.1	0+/-.1	.1+/-.1	-.2+/-.5	0+/-.01	0+/-.01	0+/-.6	-40+/-150	.4+/-1
*MEAN	5.000	1.000	0.700	0.000	0.350	-0.150	0.005	0.005	0.150	30.000	0.400
*STD. DEVIATION	2.000	1.000	0.400	0.000	0.250	0.050	0.0050	0.0050	0.150	70.000	0.400
COEFF./VARIATION	0.400	1.000	0.571	UNDETERM.	0.714	-0.333***	1.000	1.000	1.000	2.333***	1.000
APP. STAT. METHOD	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE
*T.INTERVAL(U.LIMIT)	5.000	1.000	0.7000	0.000	0.350	-0.150	0.005	0.005	0.150	30.000	---
MEAN + 3 STD. DEV.	11.000	4.000	1.900	0.000	1.100	0.000	0.020	0.020	0.600	240.000	1.600

Notes: Because of results on other radionuclides, Radium 228 was not run on Background Weathered Sandstone Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-19

BACKGROUND DISSOLVED METALS RESULTS

UNWEATHERED SANDSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	ALUMINUM	ARSENIC	CALCIUM	POTASSIUM	MANGANESE	MOLYBDENUM	SODIUM	SELENIUM	STRONTIUM	ZINC
NUMBER OF SAMPLES	7	7	7	7	7	7	7	7	7	7
NUMBER OF DETECTS	1	2	6	3	1	1	7	3	2	5
PERCENT DETECTS	14	29	86	43	14	14	100	43	29	71
MAXIMUM DETECTED VALUE	.327	.0186	39.6	21.89	.0182	.112	454	.041	.451	.374
MINIMUM DETECTED VALUE	.327	.0106	8.05	5.2	.0182	.112	64.8	.0076	.446	.0299
*MEAN	---	---	17.29	---	---	---	166	---	---	.06
*STANDARD DEVIATION	---	---	13.9	---	---	---	127	---	---	.15
*COEFFICIENT OF VARIATION	---	---	.8039	---	---	---	.7651	---	---	2.5***
MAXIMUM REPORTED DETECTION LIMIT	.200	.0100	5	5	.015	.10	---	.005	1	.02
MINIMUM REPORTED DETECTION LIMIT	.200	.0100	5	5	.015	.10	---	.005	1	.02
APPROPRIATE STATISTICAL METHOD	TP	TP	TIN	TP	TP	TP	TIN	TP	TP	TIN
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	64.6	---	---	---	599	---	---	.564
MEAN + 3 STD. DEVIATION	---	---	58.99	---	---	---	547	---	---	.51
ARAR VALUE	5.0	0.05	NS	NS	0.05	0.1	NS	0.01	NS	2.0

Notes: Dissolved Metals not detected in Unweathered Sandstone: Sb,Ba,Be,Cd,Cs,Cr,Co,Cu,Fe,Pb,Li,Mg,Hg,Ni,Ag,Tl,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-20

OTHER BACKGROUND INORGANIC RESULTS

UNWEATHERED SANDSTONE GROUND WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	CARBONATE	TDS
NUMBER OF SAMPLES	7	7	7	7	7	7	7
NUMBER OF DETECTS	6	4	7	5	7	6	7
PERCENT DETECTS	86	57	100	71	100	86	100
MAXIMUM DETECTED VALUE	360	.35	9.5	620	270	31	1300
MINIMUM DETECTED VALUE	4.7	.06	8.5	8	67	6	230
*MEAN	115	.06	9.0	71.2	164	14.7	539
*STANDARD DEVIATION	145	.16	.39	259	73	10.03	360
*COEFFICIENT OF VARIATION	1.3***	2.7***	.0433	3.6***	.4451	.6823	.6679
MINIMUM REPORTED DETECTION LIMIT	3	.05	---	5	---	5	---
MAXIMUM REPORTED DETECTION LIMIT	3	.05	---	5	---	5	---
APPROPRIATE STATISTICAL METHOD	TIN	TIN	TIN	TIN	TIN	ANOVA	TIN
*TOLERANCE INTERVAL(UPPER LIMIT)	607	.610	10.57	950	412	49	1761
**TOLERANCE INTERVAL(LOWER LIMIT)	---	---	7.43	---	---	---	---
MEAN + 3 STD. DEVIATION	550	0.54	10.2	848	383	44.8	1619
MEAN - 3 STD. DEVIATION	---	---	7.8	---	---	---	---

Notes: Ions not detected in Unweathered Sandstone: Cyanide

*Toleeance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-21

BACKGROUND DISSOLVED RADIOCHEMICAL RESULTS

UNWEATHERED SANDSTONE GROUND WATER

(ROUND 1, 1989) (CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM
NUMBER OF SAMPLES	5	5	7	7	7	6	7	7	6	5
MAX. VALUE	13+/-5	15+/-4	7.5+/-.7	.1+/-.1	1.9+/-.3	.2+/-.5	0+/-.01	.01+/-.01	.7+/-.5	330+/-160
MIN. VALUE	-2+/-4	3+/-2	.1+/-.1	0+/-.1	0+/-.1	-.3+/-.3	0+/-.01	0+/-.01	-.1+/-.5	-110+/-220
*MEAN	4.800	7.600	2.486	0.014	0.629	-0.017	0.000	0.003	0.250	42.000
*STD. DEVIATION	7.098	7.162	3.075	0.035	0.803	0.195	0.000	0.0046	0.277	164.178
COEFF./VARIATION	0.208	0.942	1.237***	2.500***	1.277***	-11.471***	UNDETERM.	1.533***	1.108***	3.909***
APP. STAT. METHOD	ANOVA	ANOVA	TIN	TIN	TIN	ANOVA	TIN	TIN	ANOVA	ANOVA
*T.INTERVAL(U.LIMIT)	34.627	37.695	12.936	0.135	3.3507	0.707	0.000	0.019	1.276	731.876
MEAN + 3 STD. DEV.	26.094	29.086	11.711	0.119	3.038	0.568	0.000	0.017	1.0811	534.534

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on Background Unweathered Sandstone Groundwater Samples

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

distribution are calculated in these tables. Of these, two analytes had a coefficient of variation greater than one or less than zero suggesting recalculation of lognormal tolerance interval may be appropriate.

The ground water sampled within unweathered sandstones is distinct from the ground waters associated with the surficial flow system. Unweathered sandstone ground water is much higher in sodium, sulfate, chloride, and TDS than any of the previously discussed water. It is also lower in nitrate than the bedrock waters. Arsenic and aluminum are trace metals detected in the unweathered sandstone ground water that were not detected elsewhere. The uranium concentrations are most similar to the weathered claystone, colluvial, and valley fill ground water.

4.2 SURFACE WATER

As presented in Section 3.2, surface water sampling sites were selected within the Rock Creek, Walnut Creek and Woman Creek drainages. Stiff diagrams for Round 1, 1989 surface water samples at various locations are presented in Plate 2.

Surface water gradually changes from the west (upgradient) to the east (downgradient) (Plate 2). The Stiff diagrams indicate that surface water becomes relatively less concentrated in sodium chloride and more concentrated in calcium bicarbonate as it flows from west to east. Downgradient Stiff diagrams of surface water resemble those Stiff diagrams of adjacent ground water. The change in the shape of the surface water Stiff diagrams across the Rocky Flats Plant reflects changing surface water/ground water interactions. Surface water stations at the western edge of the Plant are not in an incised drainage thus the surface water sampled is likely recharging the ground-water flow system. Surface water stations further east are located within an incised drainage and the geochemistry of the surface waters reflects the ground-water recharge of the surface water flow system.

4.2.1 Round 1 Surface Water Samples

Statistical summaries of chemical results are presented in Tables 4-22 through 4-26. Thirty eight tolerance intervals based on a normal distribution are presented. For eleven of these analytes a lognormal tolerance interval may be appropriate because the coefficient of variation was greater than one or less than zero.

Comparisons of the dissolved and total metals results (Table 4-22 and 4-23), and the dissolved and total radiochemical results (Table 4-25 and 4-26) indicate that most of the chemical load is transported in suspension.

A review of the data (Appendix A) upon which these summaries are based indicates that water chemistry at location SW080 appears distinct from other surface water sampling locations. Surface water from SW080 contributed the only detection of the following total metals: barium, beryllium, cadmium, cesium, chromium, cobalt, copper, magnesium, molybdenum, nickel, potassium, tin, and vanadium and the highest values of the following total metals: aluminum, arsenic, calcium, iron, lead, silver, strontium, and zinc. Surface water from SW080 contributed the highest values for gross alpha and beta. The reason for these anomalies could be attributed to the elevated concentration of total suspended solids. Analytical results from this station for the dissolved analytes appear to be consistent with result from other surface water stations.

4.2.2 Round 2 Surface Water Samples

Statistical summaries of chemical results are presented in Tables 4-27 through 4-30. Surface water from Round 2 sampling was not analyzed for dissolved radiochemical results. The suite of surface water stations sampled in Round 2 was reduced to seven because two stations, SW004 and SW080, previously sampled in Round 1 were dry.

TABLE 4-22

BACKGROUND DISSOLVED METAL RESULTS

SURFACE WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	SILVER	ALUMINUM	CALCIUM	IRON	MERCURY	MAGNESIUM	MANGANESE	SODIUM	LEAD	STRONTIUM	ZINC
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9
NUMBER OF DETECTS	1	1	9	3	7	7	5	9	1	8	2
PERCENT DETECTS	11	11	100	33	78	78	56	100	11	89	22
MAXIMUM DETECTED VALUE	.0125	.485	78.4	4.69	.0013	10	.48	32.3	.0055	.296	.032
MINIMUM DETECTED VALUE	.0125	.485	15.3	1.78	.00029	5.82	.0396	8.38	.0055	.124	.0242
*MEAN	---	---	35.5	---	.0004	6.57	.04	20.03	---	.17	---
*STANDARD DEVIATION	---	---	20.98	---	.0004	1.79	.26	8.17	---	.06	---
*COEFFICIENT OF VARIATION	---	---	.5909	---	1.0	.2725	6.5***	.4079	---	.3529	---
MAXIMUM REPORTED DETECTION LIMIT	.01	.2	---	.1	.0002	5	.015	---	.005	.1	.02
MINIMUM REPORTED DETECTION LIMIT	.01	.2	---	.1	.0002	5	.015	---	.01	.1	.02
APPROPRIATE STATISTICAL METHOD	TP	TP	TIN	TP	TIN	TIN	TIN	TIN	TP	TIN	TP
*TOLERANCE INTERVAL(UPPER LIMIT)	---	---	99.14	---	.002	11.98	.826	44.81	---	.35	---
MEAN + 3 STD. DEVIATION	---	---	98.44	---	.0016	11.94	.82	41.54	---	.35	---
ARAR VALUE	0.05	5.0	NS	0.3	0.002	NS	0.05	NS	0.05	NS	2.0

Notes: Dissolved Metals not detected in Round One Background Surface Water: Sb,As,Ba,Be,Cd,Cr,Cs,Co,Cu,Li,Mo,Ni,K,Se,Tl,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-23

BACKGROUND TOTAL METAL RESULTS

SURFACE WATER (ROUND 1, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	Ag	Al	As	Ba	Be	Ca	Cd	Cs	Co	Cr	Cu
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9
NUMBER DETECTS	3	3	2	1	1	9	1	1	1	1	1
PERCENT DETECTS	33	33	22	11	11	100	11	11	11	11	11
MAX. DET. VALUE	.148	64.10	.116	4.49	.0097	226	.0690	2.53	.0730	.0598	.180
MIN. DET. VALUE	.0106	.916	.0105	4.49	.0097	14.80	.0690	2.53	.0730	.0598	.180
*MEAN	---	---	---	---	---	59.23	---	---	---	---	---
*STD. DEVIATION	---	---	---	---	---	64.30	---	---	---	---	---
COEFF.OF VARIATION	---	---	---	---	---	1.1***	---	---	---	---	---
MAX DET. LIMIT	.0100	.200	.010	.200	.0050	---	.0050	1	.0500	.0100	.0250
MIN DET. LIMIT	.0100	.200	.010	.200	.0050	---	.0050	1	.0500	.0100	.0250
APP. STAT. METHOD	TP	TP	TP	TP	TP	TIN	TP	TP	TP	TP	TP
*T.INTERVAL(U.LIMIT)	---	---	---	---	---	254.11	---	---	---	---	---
MEAN + 3 STD. DEV.	---	---	---	---	---	252.1	---	---	---	---	---
ARAR VALUE	0.05	5.0	0.05	1.0	0.1	NS	0.01	NS	0.022U	0.05	0.2

	Fe	Hg	K	Mg	Mn	Mo	Ni	Na	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	9	8	9	9	9	9	9	9	9	9	9	9	9
NUMBER DETECTS	9	7	1	8	6	1	1	9	2	8	1	1	4
PERCENT DETECTS	100	88	11	89	67	11	11	100	22	89	11	11	44
MAX. DET. VALUE	651	.0011	9.86	24.90	.716	.199	.250	30.80	.233	1.20	.969	.364	.7
MIN. DET. VALUE	.118	.00022	9.86	5.76	.0175	.199	.250	12.50	.0185	.123	.969	.364	.0
*MEAN	75.24	.00039	---	8.86	0.10	---	---	20.444	---	0.28	---	---	--
*STD. DEVIATION	203.68	.0003	---	6.22	0.34	---	---	7.45	---	0.35	---	---	--
COEFF.OF VARIATION	2.7***	.7692	---	.7020	3.4***	---	---	.3644	---	1.3***	---	---	--
MAX DET. LIMIT	---	.0002	5	5	.0150	.100	.0400	---	.005	.100	.100	.0500	.0
MIN DET. LIMIT	---	.0002	5	5	.0150	.100	.0400	---	.0050	.100	.100	.0500	.0
APP. STAT. METHOD	TIN	TIN	TP	TIN	TIN	TP	TP	TIN	TP	TIN	TP	TP	TP
*T.INTERVAL(U.LIMIT)	692.59	0.001	---	27.71	1.140	---	---	43.020	---	1.341	---	---	--
MEAN + 3 STD. DEV.	686.3	0.0013	---	27.5	1.12	---	---	42.794	---	1.33	---	---	--
ARAR VALUE	0.3	0.002	NS	NS	0.05	0.1	0.2	NS	0.05	NS	NS	0.1	2.

Notes: Total Metals not detected in Round One Background Surface Water:Sb,Li,Se,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-24

OTHER BACKGROUND INORGANIC RESULTS

SURFACE WATER (ROUND 1, 1989)

(CONCENTRATIONS IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS
NUMBER OF SAMPLES	9	9	9	9	9	9
NUMBER OF DETECTS	9	7	9	8	9	9
PERCENT DETECTS	100	78	100	89	100	100
MAXIMUM DETECTED VALUE	62	2.0	8.1	34	320	290
MINIMUM DETECTED VALUE	5	0.12	6.5	16	30	120
*MEAN	23.11	0.58	7.456	20.92	130.67	177.78
*STANDARD DEVIATION	21.77	0.62	0.44	9.66	85.47	50.06
*COEFFICIENT OF VARIATION	0.9420	1.1***	0.0590	0.4618	0.6541	0.2816
MINIMUM REPORTED DETECTION LIMIT	---	0.05	---	5	---	---
MAXIMUM REPORTED DETECTION LIMIT	---	0.05	---	5	---	---
APPROPRIATE STATISTICAL METHOD	TIN	TIN	TIN	TIN	TIN	TIN
*TOLERANCE INTERVAL (UPPER LIMIT)	89.11	2.45	9.02	50.20	389.72	329.52
**TOLERANCE INTERVAL(LOWER LIMIT)	---	---	5.89	---	---	327.96
MEAN + 3 STD. DEVIATION	88.42	2.44	8.78	49.9	387.08	327.96
MEAN - 3 STD. DEVIATION	---	---	6.14	---	---	---

Notes: Ions not detected in Round One Background Surface Water: Carbonate, Cyanide

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-25

BACKGROUND DISSOLVED RADIOCHEMICAL RESULTS

SURFACE WATER (ROUND 1, 1989)

(CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9
MAX. VALUE	4+/-5	6+/-3	2.6+/-.5	.3+/-.1	1.7+/-.4	.9+/-.5	.01+/-.02	0+/-.02	.2+/-.6
MIN. VALUE	-1+/-1	-2+/-2	0+/-.1	0+/-.1	-.1+/-.1	-.5+/-.8	0+/-.02	-.01+/-.03	-.5+/-.6
*MEAN	0.556	1.444	0.667	0.044	0.378	0.078	0.002	-0.003	-0.144
*STD. DEVIATION	1.732	2.603	0.995	0.105	0.638	0.452	0.005	0.006	0.243
COEFF./VARIATION	3.115***	1.803***	1.492***	2.386***	1.688***	5.795***	2.50***	-2.0***	-1.723***
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN
*T.INTERVAL(U.LIMIT)	5.805	9.335	3.684	0.364	2.311	1.452	0.017	0.014	0.591
MEAN + 3 STD. DEV.	5.752	9.253	3.652	0.359	2.292	1.434	0.017	0.015	0.588

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on Background Round One Surface Water Samples.

*Tolerance Intervals, *Coefficient of Variation*, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - *Test of Proportions*. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-26

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

SURFACE WATER AT ROCKY FLATS

(ROUND 1, 1989) (CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	3	1
MAX. VALUE	250+/-140	200+/-110	0.9+/-0.3	0.1+/-0.2	0.7+/-0.2	1.5+/-0.5	1.0+/-0.1	0.1+/-0.07	12+/-2	200+/-150	5.5+/-0.9	11+/-4
MIN. VALUE	1+/-2	0+/-3	0.1+/-0.1	0.0+/-0.1	0.0+/-0.1	-0.1+/-0.4	0.0+/-.02	-.01+/-.02	-.4+/-.5	50+/-150	.2+/-.2	11+/-4
*MEAN	32.111	26.556	0.411	0.011	0.267	0.500	0.122	0.013	1.211	115.556	2.133	---
*STD. DEVIATION	77.383	61.655	0.277	0.031	0.221	0.548	0.311	0.032	3.8196	49.690	3.849	---
COEFF./VARIATION	2.410***	2.322***	0.674	2.818***	0.828	1.096***	2.549***	2.462***	3.154***	0.430	1.805***	---
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	ANOVA	NONE
*U.INTERVAL(U.LIMIT)	266.658	213.432	1.250	0.106	0.937	2.160	1.066	0.111	12.788	266.107	---	---
MEAN + 3 STD. DEV.	264.260	211.521	1.242	0.104	0.930	2.144	1.055	0.109	12.668	264.626	13.680	---

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all Background Round One Surface Water Samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval will be calculated for final.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-27

BACKGROUND DISSOLVED METAL RESULTS

SURFACE WATER (ROUND 2, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	ALUMINUM	CALCIUM	IRON	MERCURY	LITHIUM	MAGNESIUM	MANGANESE	MOLYBDENUM	SODIUM	LEAD	ZINC
NUMBER OF SAMPLES	7	7	7	7	7	7	7	7	7	7	7
NUMBER OF DETECTS	1	7	3	2	1	6	6	6	7	1	1
PERCENT DETECTS	14	100	43	29	14	86	86	86	100	14	14
MAXIMUM DETECTED VALUE	.454	63.90	.453	.0004	.0166	11.80	.163	.0234	33.80	.0131	.0228
MINIMUM DETECTED VALUE	.454	14.50	.116	.0004	.0166	5	.0290	.0119	14.10	.0131	.0228
*MEAN	---	33.49	---	---	---	6.7	0.05	0.01	20.89	---	---
*STANDARD DEVIATION	---	17.59	---	---	---	2.66	.0522	.0051	6.57	---	---
*COEFFICIENT OF VARIATION	---	0.5252	---	---	---	0.3970	1.0	0.5100	0.3145	---	---
MAXIMUM REPORTED DETECTION LIMIT	.2	---	.100	.0002	.0100	5	.0150	.0100	---	.0050	.0200
MINIMUM REPORTED DETECTION LIMIT	.2	---	.100	.0002	.0100	5	.0150	.0100	---	.0050	.0200
APPROPRIATE STATISTICAL METHOD	TP	TIN	TP	TP	TP	TIN	TIN	TIN	TIN	TP	TP
*TOLERANCE INTERVAL (UPPER LIMIT)	---	93.27	---	---	---	15.74	0.232	0.032	43.22	---	---
MEAN + 3 STD. DEVIATIONS	---	86.26	---	---	---	14.68	0.2066	0.0253	40.6	---	---
ARAR VALUE	5.0	NS	0.3	0.002	2.5	NS	0.05	0.1	NS	0.05	2.0

Notes: Dissolved Metals not detected in Round Two Background Surface Water: Sb, As, Ba, Be, Cd, Cs, Cr, Co, Cu, Ni, K, Se, Ag, Sr, Tl, Sn, V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval will be calculated for final.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-28

BACKGROUND TOTAL METAL RESULTS

SURFACE WATER (ROUND 2, 1989)

(CONCENTRATIONS IN mg/l)

	ALUMINUM	BARIUM	CALCIUM	CHROMIUM	IRON	MERCURY	LITHIUM	MAGNESIUM	MANGANESE	MOLYBDENUM	SODIUM	LEAD	ZINC
NUMBER OF SAMPLES	7	7	7	7	7	7	7	7	7	7	7	7	7
NUMBER OF DETECTS	6	1	7	2	7	3	1	5	7	7	7	1	3
PERCENT DETECTS	86	14	100	29	100	43	14	71	100	100	100	14	43
MAXIMUM DETECTED VALUE	4.98	.294	69.40	.0115	7.94	.0004	.0192	12.30	.837	.0203	33.30	.0308	.0892
MINIMUM DETECTED VALUE	.236	.294	16.30	.0106	.360	.0003	.0192	5.91	.0162	.0105	15.20	.0308	.0562
*MEAN	1.89	---	35.543	---	3.127	---	---	6.49	0.233	0.014	21.343	---	---
*STANDARD DEVIATION	1.93	---	20.44	---	2.63	---	---	3.26	0.26	0.0034	6.27	---	---
*COEFFICIENT OF VARIATION	1.0	---	0.5751	---	0.8411	---	---	0.5023	1.1***	0.2429	0.2938	---	---
MAXIMUM REPORTED DETECTION LIMIT	.200	.200	---	.0100	---	.0002	.0100	5	---	---	---	.0050	.0200
MINIMUM REPORTED DETECTION LIMIT	.200	.200	---	.0100	---	.0002	.0100	5	---	---	---	.0050	.0200
APPROPRIATE STATISTICAL METHOD	TIN	TP	TIN	TP	TIN	TP	TP	TIN	TIN	TIN	TIN	TP	TP
*TOLERANCE INTERVAL (UPPER LIMIT)	8.444	---	105.03	---	12.070	---	---	17.578	1.101	0.026	42.651	---	---
MEAN • 3 STD. DEVIATION	7.68	---	96.863	---	11.017	---	---	16.27	1.013	0.0242	40.153	---	---
ARAR VALUE	5.0	1.0	NS	0.05	0.3	0.002	2.5	NS	0.05	0.1	NS	0.05	2.0

Notes: Total Metals not detected in Round Two Background Surface Water: Sb,As,Be,Cd,Cs,Co,Cu,Ni,K,Se,Ag,Sr,Tl,Sn,V

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval will be calculated for final.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

NS - No Standard

TABLE 4-29

OTHER BACKGROUND INORGANIC RESULTS

SURFACE WATER (ROUND 2, 1989)

(CONCENTRATIONS REPORTED IN mg/l)

	CHLORIDE	NITRATE AS N	pH	SULFATE	BICARBONATE	TDS	CYANIDE
NUMBER OF SAMPLES	7	7	7	7	7	7	7
NUMBER OF DETECTS	7	3	7	7	7	7	1
PERCENT DETECTS	100	43	100	100	100	100	14
MAXIMUM DETECTED VALUE	62	2.1	7.7	46	230	280	.0043
MINIMUM DETECTED VALUE	4	0.16	7.0	13	56	140	.0043
*MEAN	17.143	---	7.371	31.143	126.86	191.43	---
*STANDARD DEVIATION	19.25	---	0.23	10.05	63.95	51.11	---
*COEFFICIENT OF VARIATION	1.1***	---	.0312	0.3227	0.5041	0.2670	---
MINIMUM REPORTED DETECTION LIMIT	---	0.05	---	---	---	---	.0025
MAXIMUM REPORTED DETECTION LIMIT	---	0.05	---	---	---	---	.0025
APPROPRIATE STATISTICAL METHOD	TIN	TP	TIN	TIN	TIN	TIN	TP
*TOLERANCE INTERVAL (UPPER LIMIT)	82.56	---	8.30	65.30	344.21	365.15	---
**TOLERANCE INTERVAL (LOWER LIMIT)	---	---	6.44	---	---	---	---
MEAN + 3 STD. DEVIATION	74.89	---	8.06	61.293	318.71	344.76	---
MEAN - 3 STD. DEVIATION	---	---	6.68	---	---	---	---

Notes: Ions not detected in Round Two Background Surface Water: Carbonate ,

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval will be calculated for final.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-30

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

SURFACE WATER (ROUND 2, 1989)

(CONCENTRATIONS IN pCi/l)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226
NUMBER OF SAMPLES	7	7	7	7	7	7	7	7	7	7	1
MAX. VALUE	78+/-29	58+/-11	.7+/-.2	0+/-.1	.4+/-.2	.8+/-.5	.08+/-.03	.01+/-.01	.4+/-.7	550+/-220	1.4+/-1.0
MIN. VALUE	-2+/-4	0+/-2	.1+/-.1	0+/-.1	0+/-.1	0+/-.4	0+/-.01	0+/-.02	-.6+/-.8	-60+/-160	1.4+/-1.0
*MEAN	11.000	11.143	0.400	0.000	0.271	0.257	0.014	0.001	0.000	187.143	---
*STD. DEVIATION	28.010	20.125	0.273	0.000	0.0277	0.2902	0.028	0.004	0.312	198.92	---
COEFF./VARIATION	2.546***	1.806***	0.683	UNDETERM.	0.103	1.128***	2.000***	4.0***	UNDETERM.	1.063***	---
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	NONE
*T.INTERVAL (U.LIMIT)	106.207	79.549	1.326	0.000	0.977	1.243	0.112	0.014	1.059	863.276	---
MEAN + 3 STD. DEV.	95.03	71.518	1.219	0.000	0.355	1.127	0.098	0.013	0.936	783.903	---

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all Background Round Two Surface Water Samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

Differences in the analytical results from Round 1 and Round 2 sampling document the temporal variation in surface water chemistry. These differences include variability in the suite of detects as well as the magnitude of concentrations. Much of the differences in total metals concentrations and total radiochemical concentrations are attributable in part, to the absence of data for surface water station SW080 in Round 2; however, other differences reflect natural changes in environmental conditions (e.g. dissolved strontium detected in 8 samples in Round 1 was not detected in Round 2, dissolved molybdenum undetected in Round 1 was detected in 6 samples in Round 2).

4.3 STREAM SEDIMENTS

Background sediment sampling locations were paired with the surface water stations discussed above. Sediment sampling locations are within the drainage of Rock Creek, Walnut Creek, and Woman Creek.

Statistical summaries of chemical results are presented in Tables 4-31 and 4-32. Twenty tolerance intervals based on a normal distribution are presented. For three of these analytes a lognormal tolerance interval may be appropriate because the coefficient of variation is greater than one or less than zero.

Relative to the Rocky Flats Alluvium, colluvium, and weathered sandstone and claystone, the sediments have less detected trace metals and lower concentrations of aluminum, iron, and calcium. Trace metals not detected in the sediments but detected in the other materials include beryllium, lithium, cobalt, molybdenum, cesium, mercury, antimony, and cadmium. Potassium was also not detected in the sediments but was detected elsewhere. The absence of detected potassium, together with the lower concentrations of aluminum and iron, suggest the clay fraction is less in the sediments relative to the other materials. This is further supported by the physical description of this material, i.e., the sediments tend to be more coarse. A smaller clay fraction may also explain the fewer detections of trace metals owing to the high adsorptive capacity of the clay fraction.

TABLE 4-31

BACKGROUND TOTAL METAL RESULTS

SEDIMENTS

(CONCENTRATIONS IN mg/kg)

	SILVER	ALUMINUM	ARSENIC	BARIUM	CALCIUM	CHROMIUM	COPPER	IRON	MAGNESIUM	MANGANESE	NICKEL	LEAD	STRONTIUM	VANADIUM	ZINC
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
NUMBER OF DETECTS	1	9	1	4	5	8	4	9	4	9	3	9	3	3	9
PERCENT DETECTS	11	100	11	44	56	89	44	100	44	100	33	100	33	33	100
MAXIMUM DETECTED VALUE	6.8	21600	13.0	182	52500	30.4	22.0	22500	4110	303	29.9	25.1	175	50.2	70.3
MINIMUM DETECTED VALUE	6.8	549	13.0	56.2	1810	3.5	8.6	1040	1380	9.0	9.9	2.3	25.2	13.4	6.5
*MEAN	---	6513.9	---	---	2590	13.48	---	8692.2	---	129.39	---	11.33	---	---	31.33
*STANDARD DEVIATION	---	6029.4	---	---	23082	9.87	---	6471.8	---	80.11	---	9.29	---	---	20.24
*COEFFICIENT OF VARIATION	---	0.9256	---	---	8.9***	0.7322	---	0.7446	---	0.6191	---	0.8200	---	---	0.6460
MAXIMUM REPORTED DETECTION LIMIT	7.0	42.1	5.0	140	3340	2.4	16.2	---	3340	---	26.8	---	70.2	33.4	---
MINIMUM REPORTED DETECTION LIMIT	2.3	13.7	2.0	47.0	1180	2.4	5.9	---	1180	---	9.4	---	23.5	11.8	---
APPROPRIATE STATISTICAL METHOD	TP	TIN	TP	TP	TIN	TIN	TP	TIN	TP	TIN	TP	TIN	TP	TP	TIN
*TOLERANCE INTERVAL (UPPER LIMIT)	---	24789	---	---	72551	43.38	---	28308	---	372.20	---	39.502	---	---	92.688
MEAN + 3 STD. DEVIATION	---	24602	---	---	71836	43.09	---	28107	---	369.72	---	39.2	---	---	92.05

Notes: Total Metals not detected in Background Sediments: Sb,Be,Cd,Cs,Co,Li,Hg,Mo,K,Se,Na,Tl,Sn

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-32

OTHER BACKGROUND INORGANIC & TOTAL RADIOCHEMICAL RESULTS

SEDIMENTS

	ALPHA pCi/g	BETA pCi/g	U233,U234 pCi/g	U235 pCi/g	U238 pCi/g	Sr89,Sr90 pCi/g	Pu239,Pu240 pCi/g	Am241 pCi/g	Cs137 pCi/g	TRITIUM pCi/ml	Ra226 pCi/g	Ra228 pCi/g	pH
NUMBER OF SAMPLES	9	9	9	9	9	9	9	9	9	9	9	9	9
NUMBER DETECTS	9	9	9	9	9	9	9	9	9	9	9	9	9
PERCENT DETECTS	100	100	100	100	100	100	100	100	100	100	100	100	100
MAX. VALUE	40+/-15	40+/-7	1.2+/-0.2	.1+/-.1	1.3+/-.2	.8+/-.7	.08+/-.02	.02+/-.04	1.4+/-.1	.32+/-.15	1.0+/-.1	2.1+/-.4	7.9
MIN. VALUE	4+/-12	20+/-6	.5+/-.2	0+/-.1	.4+/-.1	-.6+/-.7	0+/-.02	-.01+/-.02	0+/-.1	.12+/-.14	.6+/-.1	1+/-.1	6.1
*MEAN	25.667	29.556	0.800	0.033	0.778	0.122	0.020	-0.001	0.244	0.203	0.756	1.300	7.211
*STD. DEVIATION	11.373	6.801	0.287	0.047	0.322	0.418	0.025	0.010	0.440	0.068	0.107	0.346	0.52
COEFF./VARIATION	0.443	0.230	0.351	1.424***	0.414	3.426***	0.1750***	-10.00***	1.803***	0.335	0.142	0.266	0.072
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN
*T.INTERVAL (U.LIMIT)	60.137	50.168	1.669	0.176	1.755	1.390	0.096	0.029	1.578	0.408	1.079	2.350	9.03
MEAN + 3 STD. DEV.	59.780	49.959	1.661	0.174	1.744	1.376	0.095	0.029	1.564	0.611	1.077	2.338	8.77
MEAN - 3 STD. DEV.	---	---	---	---	---	---	---	---	---	---	---	---	5.65

Notes: Ions not detected in Background Sediment Samples: Nitrate.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

4.4 BOREHOLE MATERIALS

Borehole materials were collected within the Rocky Flats Alluvium, colluvium, weathered claystone and weathered sandstone.

4.4.1 Rocky Flats Alluvium

Rocky Flats Alluvium is a poorly sorted, unconsolidated deposit of gravels (granule to cobbles and boulders) with clay, silt and sand matrices. Gravel is primarily quartzite and granite fragments and may be weathered; sand is primarily composed of quartz grains. Caliche is locally present. The surficial sample from Rocky Flats Alluvium may contain 0 to 3 feet of topsoil which varies from sandy gravel to silty clay.

Statistical summaries of chemical results are presented in Tables 4-33, 4-34 and 4-35. Eighteen tolerance intervals based on a normal distribution are presented. For four of these analytes a lognormal tolerance interval may be appropriate because the coefficient of variation is in excess of one. Sixteen of these analytes have at least one detection in excess of the calculated tolerance interval. At least in part this is a reflection of the large number of samples (70 samples) which increases the probability of sampling outside of the 95% tolerance interval.

A review of the data did not reveal any specific sampling location associated with analyte concentrations in excess of the tolerance limit. The review did suggest that certain analytes such as aluminum and lead tended to be in higher concentrations near surface, and that elevated concentrations of multiple analytes tended to cluster within the same sample.

4.4.2 Colluvium

Colluvium is located on the sides and bases of hills and slopes. A product of mass wasting and downslope creep, colluvium is a poorly sorted mixture of topsoil, weathered

TABLE 4-33

BACKGROUND TOTAL METAL RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
NUMBER DETECTS	20	70	44	55	60	68	6	14	70	61	70	19	36	39	65	70	41	56	69	10	21	67	65
PERCENT DETECTS	29	100	63	79	86	97	9	20	100	87	100	27	51	56	93	100	59	80	99	14	30	96	93
MAX. VALUE	40.9	40800	41.7	209	19.0	157000	3.2	18.2	69.6	31.6	33700	0.58	4020	31.3	5570	656	41.0	54.2	21.9	226	338	70.0	77.6
MIN. VALUE	2.8	2240	1.2	43.8	1.0	1130	1.3	11.1	4.0	5.5	4670	0.12	1100	3.7	1180	26.6	2.5	8.8	2.6	23.3	27.3	11.7	4.3
*MEAN	---	11831	3.23	68.9	3.63	5702	---	---	17.2	9.58	12584	---	1061	18.4	2261.2	181.3	17.04	17.81	7.72	---	---	27.75	22.67
*STD. DEVIATION	---	6788	6.36	43.7	3.84	18821	---	---	10.5	5.26	5202	---	1146	13.1	1089.6	121.7	10.88	12.82	5.19	---	---	13.55	15.09
COEFF./VARIATION	---	.5737	2.0***	.6343	1.1***	3.3***	---	---	.6105	.5491	.4134	---	1.1***	.7120	.4819	.6713	.6385	.7198	.6723	---	---	.4883	.6656
MAX DET. LIMIT	4.8	---	4.9	50.1	1.3	1170	2.4	24.2	---	6.3	---	0.24	1250	25.5	1170	---	25.5	10.2	4.2	484	48.4	11.7	4.3
MIN DET. LIMIT	2.0	---	1.7	40.4	1.1	1160	1.0	10.1	---	5.1	---	0.083	1010	2.0	1010	---	2.0	8.7	4.2	20.3	20.2	10.7	4.0
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TIP	TP	TIN	TIN	TIN	TP	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TP	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	25312	15.86	155.8	11.27	43079	---	---	37.9	20.03	22916	---	3336	44.4	4425	422.9	38.65	43.27	18.04	---	---	54.67	52.64
MEAN + 3 STD. DEV.	---	32195	22.3	200.0	15.2	62165	---	---	48.7	25.4	28190	---	4499	57.7	5530	546.4	49.7	56.3	23.3	---	---	68.4	67.94

Notes: Total Metals not detected in Background Borehole Alluvium: Sb,Cs,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-34

OTHER BACKGROUND INORGANIC RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	70	70	70
NUMBER DETECTS	16	23	70
PERCENT DETECTS	23	33	100
MAX. VALUE	13	4.3	9.1
MIN. VALUE	2	1.1	6.1
*MEAN	---	---	7.846
*STD. DEVIATION	---	---	0.78
COEFF./VARIATION	---	---	0.0994
MAX DET. LIMIT	4	2.2	---
MIN DET. LIMIT	2	1.0	---
APP. STAT. METHOD	TP	TP	TIN
**T.INTERVAL(L.LIMIT)	---	---	6.06
*T.INTERVAL(U. LIMIT)	---	---	9.64
MEAN + 3 STD. DEV.	---	---	10.186
MEAN - 3 STD. DEVIATI	---	---	5.506

Notes:

*Tolerance Intervals not calculated when the number of samples is less thag seven.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal *Distribution*

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-35

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

ROCKY FLATS ALLUVIUM

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	70	70	70	70	70	69	70	21	70	70	55	55
NUMBER DETECTS	70	70	70	70	70	69	70	21	70	70	55	55
PERCENT DETECTS	100	100	100	100	100	100	100	100	100	100	100	100
MAX. VALUE	40+/-16	44+/-7	3.4+/-0.2	0.2+/-0.1	3.2+/-0.2	1.2+/-1.0	0.03+/-0.03	0.01+/-0.03	0.2+/-0.1	0.44+/-0.16	0.9+/-0.1	2.2+/-0.3
MIN. VALUE	3+/-7	6+/-5	0.2+/-0.2	0.0+/-0.1	0.2+/ 0.1	-0.6+/-0.7	-0.01+/-0.02	-0.02+/-0.02	0.0+/-0.1	-0.15+/-0.15	0.4+/-0.1	0.5+/-0.2
MEAN	21.387	23.600	0.633	0.013	0.639	0.055	0.002	-0.002	0.009	0.177	0.629	1.325
*STD. DEVIATION	7.9157	6.6899	0.4322	0.0375	0.3595	0.3586	0.0073	0.0085	0.0368	0.1175	0.3461	0.7575
COEFF./VARIATION	0.3701	0.2835	0.6829	2.9165*	0.5629	6.5117*	2.9984*	-4.4394*	4.2947*	0.6639	0.5502	0.5715
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	37.108	36.886	1.491	0.087	1.353	0.768	0.017	0.018	0.082	0.410	1.334	2.868
MEAN + 3 STD. DEV.	45.1343	43.6696	1.9294	0.1254	1.7170	1.1309	0.0242	0.0235	0.1190	0.5295	1.6675	3.5979

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

bedrock and reworked Rocky Flats Alluvium. Colluvium is comprised of silty clay and clayey silt with some quartzite gravel. It is weathered and sometimes sandy. Caliche is present at some locations. As much as two feet of topsoil may overlie the colluvium. It consists of silty clay often organic rich and with trace to some quartzite gravels.

Statistical summaries of chemical results are presented in Tables 4-36, 4-37, and 4-38. Twenty tolerance intervals based on a normal distribution are presented. A lognormal tolerance interval for beryllium may be appropriate because the coefficient of variance is in excess of one. Fourteen of these analytes have at least one detection in excess of the tolerance interval.

The suite of detected analytes within colluvium are the same suite of analytes detected in Rocky Flats Alluvium plus two additional analytes: cesium and sodium. The calculated mean concentration for most analytes is slightly greater within colluvium than within Rocky Flats Alluvium.

4.4.3 Weathered Claystone

Weathered claystone is the most common lithology comprising weathered bedrock. Weathered claystone is medium hard, consolidated, and locally fractured. It is silty or sandy and often contains carbonaceous debris.

Statistical summaries of chemical results are presented in Tables 4-39, 4-40 and 4-41. Eighteen tolerance intervals based on a normal distribution are presented. A lognormal tolerance interval for arsenic and manganese may be appropriate because the coefficient of variation is in excess of one. Six of the analytes have one detection in excess of the upper tolerance limit.

TABLE 4-36

BACKGROUND TOTAL METAL RESULTS

COLLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cs	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
NUMBER DETECTS	8	28	20	27	27	28	1	3	28	2	27	28	8	15	22	28	28	21	2	25	28	28	5	27	28
PERCENT DETECTS	29	100	71	96	96	100	4	11	100	7	96	100	29	54	79	100	100	75	7	89	100	100	18	96	100
MAX. VALUE	33.5	22900	6.6	491	22.4	25900	1.8	15.9	26.9	274	28	35900	.44	3090	18.0	5580	747	26.8	3680	36.2	29.9	121	441	58.8	111
MIN. VALUE	2.5	4630	2.4	45.2	2.0	3020	1.8	13.0	6.1	234	6.4	6860	.10	1250	3.8	1540	37.0	3.5	301	9.6	6.6	25.1	285	15.3	23.9
*MEAN	---	10849	3.31	128.8	5.35	8328	---	---	13.8	---	14.5	14798	---	1235	12.4	3177	193.4	15.95	---	16.9	16.2	56.9	---	29.9	53.0
*STD. DEVIATION	---	4808	1.97	96.49	5.51	5550	---	---	5.8	---	5.4	6756	---	691	8.8	1322	156.4	7.48	---	8.2	4.5	24.1	---	12.6	20.1
COEFF./VARIATION	---	.4432	.5952	.7491	1.0	.6664	---	---	.4203	---	.3724	.4565	---	.5595	.7097	.4161	.8087	.4690	---	.4852	.2778	.4236	---	.4214	.3792
MAX DET. LIMIT	2.6	---	2.5	45.4	1.1	---	1.3	12.9	---	258	6.1	---	.13	1220	24.8	---	---	24.8	1290	9.8	---	---	25.8	11.9	---
MIN DET. LIMIT	2.2	---	1.0	45.4	1.1	---	1.1	10.8	---	216.2	6.1	---	.097	1100	22.1	---	---	2.2	1080	9.5	---	---	22.5	11.9	---
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TIN	TP	TIN	TIP	TIN	TIN	TP	TIN	TIN	TIN	TIN	TIN	TIP	TIN	TIN	TIN	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	21663	7.7	345.8	17.75	20811	---	---	26.8	---	26.7	29991	---	2789	32.1	6151	545.1	32.78	---	35.4	26.4	111.1	---	58.2	98.1
MEAN+3 STD. DEV.	---	25273	9.2	418.3	21.9	24978	---	---	31.2	---	30.7	35066	---	3308	38.8	7143	662.6	38.4	---	41.5	29.7	129.2	---	67.7	113.3

Notes: Total Metals not detected in Background Borehole Colluvium: Sb,Se,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-37

OTHER BACKGROUND INORGANIC RESULTS

COLLUVIUM

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	28	28	28
NUMBER DETECTS	6	15	28
PERCENT DETECTS	21	54	100
MAX. VALUE	5	3.7	9.1
MIN. VALUE	2	1.1	7.2
*MEAN	---	1.35	8.221
*STD. DEVIATION	---	1.30	0.49
COEFF./VARIATION	---	0.9629	0.0596
MAX DET. LIMIT	4	1.3	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	TIN	TIN
**T.INTERVAL(L.LIMIT)	---	---	6.96
*T.INTERVAL (U.LIMIT)	---	4.274	9.48
MEAN + 3 STD. DEV.	---	5.25	9.691
MEAN - 3 STD. DEVIATI			6.751

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-38

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

COLLUVIUM

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	28	28	28	28	28	28	28	0	28	28	21	21
NUMBER DETECTS	28	28	28	28	28	28	28	0	28	28	21	21
PERCENT DETECTS	100	100	100	100	100	100	100	0	100	100	100	100
MAX. VALUE	48+/-17	34+/-6	2.6+/-0.5	0.2+/-0.1	2.3+/-0.4	0.8+/-0.7	0.02+/-0.02	---	0.2+/-0.1	0.24+/-0.16	1.3+/-0.1	2.1+/-0.3
MIN. VALUE	19+/-10	20+/-6	0.4+/-0.1	0.0+/-0.1	0.4+/-0.2	-0.6+/-0.8	0.00+/-0.02	---	0.0+/-0.1	-0.14+/-0.15	0.7+/-0.1	1.1+/-0.2
*MEAN	31.536	26.750	0.839	0.043	0.925	-0.011	0.006	---	0.014	0.060	1.067	1.567
*STD. DEVIATION	8.9701	3.7285	0.4091	0.0562	0.3334	0.3498	0.0077	---	0.0440	0.1064	0.6433	0.9494
COEFF./VARIATION	0.2844	0.1394	0.4875	1.3123*	0.3604	-32.6514*	1.2712*	---	3.0822*	1.7831*	0.6031	0.6060
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	---	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	51.710	35.135	1.759	0.169	1.675	0.776	0.023	---	0.113	0.299	2.592	3.818
MEAN + 3 STD. DEV.	58.4461	37.9355	2.0667	0.2116	1.9252	1.0388	0.0292	---	0.1464	0.3787	2.9966	4.4148

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-39

BACKGROUND TOTAL METAL RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Co	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo	Ni	Pb	Sb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
NUMBER DETECTS	3	17	9	16	17	17	2	17	17	17	6	4	12	16	17	12	13	17	2	17	2	16	17
PERCENT DETECTS	18	100	53	94	100	100	12	100	100	100	35	24	71	94	100	71	76	100	12	100	12	94	100
MAX. VALUE	18.7	13900	10.8	243	16.1	9970	29.7	13.7	26.7	38100	.35	1400	10.4	5600	737	12.1	62.4	29.5	16.2	141	274	46.4	99.5
MIN. VALUE	2.4	3160	2.5	47.9	1.2	3120	15.3	3.0	6.5	2940	.18	1290	2.7	1510	11.6	2.8	10.2	10.8	13.6	29.7	190	11.0	24.1
*MEAN	---	7430	2.9	100.6	3.5	5762	---	8.98	16.8	14794	---	---	11.97	2320	178	12.36	17.19	20.1	---	75.04	---	22.7	63.2
*STD. DEVIATION	---	2440	4.88	56.1	3.4	1778	---	3.05	5.5	10660	---	---	8.61	1036	192	8.58	15.99	5.8	---	27.91	---	9.3	17.5
COEFF./VARIATION	---	.3284	1.7***	.5577	.9714	.3086	---	.3396	.3274	.7206	---	---	.7193	.4466	1.1***	.6942	.9302	.2886	---	.3719	---	.4097	.2769
MAX DET. LIMIT	2.6	---	2.5	46.9	---	---	12.9	---	---	---	.13	1290	24.8	1060	---	24.8	9.4	---	2.5	---	25.8	10.6	---
MIN DET. LIMIT	2.1	---	2.1	46.9	---	---	10.6	---	---	---	.11	1060	2.1	1060	---	2.1	8.5	---	2.1	---	21.2	10.6	---
APP. STAT. METHOD	TP	TIN	TIN	TIN	TIN	TIN	TP	TIN	TIN	TIN	TP	TP	TIN	TIN	TIN	TIN	TIN	TIN	TP	TIN	TP	TIN	TIN
*T.INTERVAL(U.LIMIT)	---	13495	15.05	240.1	11.8	10183	---	16.57	30.62	41295	---	---	33.37	4896	656	33.68	56.95	34.5	---	144.42	---	47.7	106.7
MEAN + 3 STD. DEV.	---	14750	17.5	268.9	13.7	11096	---	18.13	33.3	46774	---	---	37.8	5428	754	38.1	65.2	37.5	---	158.8	---	50.6	115.7

Notes: Total Metals not detected in Background Borehole Claystone: Cd,Cs,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-40

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	17	17	17
NUMBER DETECTS	4	7	17
PERCENT DETECTS	24	41	100
MAX. VALUE	5	2.0	9.7
MIN. VALUE	2	1.1	7.6
*MEAN	---	---	8.588
*STD. DEVIATION	---	---	0.54
COEFF./VARIATION	---	---	0.0629
MAX DET. LIMIT	4	1.2	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	TP	TIN
**T.INTERVAL(L.LIMIT)	---	---	7.04
*T.INTERVAL (U.LIMIT)	---	---	10.14
MEAN + 3 STD. DEV.	---	---	10.208
MEAN - 3 STD. DEVIATI			6.968

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total *(background & nonbackground)* detects >= 5

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-41

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

WEATHERED CLAYSTONE

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	17	17	17	17	17	17	17	0	17	17	12	12
NUMBER DETECTS	17	17	17	17	17	17	17	0	17	17	12	12
PERCENT DETECTS	100	100	100	100	100	100	100	0	100	100	100	100
MAX. VALUE	46+/-17	32+/-6	1.7+/-0.4	0.3/-0.1	1.4+/-0.3	0.7+/-0.6	0.01+/-0.02	---	0.0+/-0.1	0.28+/-0.14	1.3+/-0.1	1.6+/-0.2
MIN. VALUE	17+/-14	18+/-5	0.4+/-0.1	0.0+/-0.1	0.5+/-0.2	-0.7+/-0.7	-0.01+/-0.02	---	0.0+/-0.1	-0.11+/-0.15	0.9+/-0.1	1.1+/-0.2
*MEAN	30.059	25.471	1.035	0.047	1.012	-0.118	0.004	---	0.000	0.052	1.100	1.333
*STD. DEVIATION	8.9474	4.1319	0.3819	0.0848	0.2541	0.3634	0.0068	---	0.0000	0.1086	0.7194	0.8773
COEFF./VARIATION	0.2977	0.1622	0.3688	1.8028*	0.2511	-3.0887*	1.9293*	---	---	2.0987*	0.6540	0.6580
APP. STAT. METHOD	TIN	TIN	TIN	TIN	TIN	TIN	TIN	---	TIN	TIN	TIN	TIN
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	52.302	35.743	1.985	0.258	1.643	0.786	0.020	---	0.000	0.322	3.068	3.734
MEAN + 3 STD. DEV.	56.9009	37.8663	2.1809	0.3016	1.7741	0.9725	0.0240	---	0.0000	0.3777	3.2581	3.9652

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

The suite of detected analytes is comparable to that detected in the Rocky Flats Alluvium except that cadmium is detected only in Rocky Flats Alluvium and antimony is only detected in weathered claystone.

4.4.4 Weathered Sandstone

Weathered sandstone is very fine to medium grained, and oxidized. It is carbonaceous and silty or interbedded with clayey lenses. It ranges from unconsolidated to consolidated.

Statistical summaries of chemical results are presented in Tables 4-42, 4-43 and 4-44. Only four samples are available for weathered sandstone and consequently no tolerance intervals can be generated.

The suite of analytes detected in weathered sandstone is the same as that suite detected in weathered claystone with the exception of potassium and antimony which were not detected within weathered sandstone. Within weathered claystone, potassium is detected 4 out of 17 samples for a 24% detection rate and antimony is detected in 2 out of 17 samples for a 12% detection rate. This probably results from a common chemical composition of the clay sized materials present in both lithologies.

The maximum value of each analyte detected within weathered sandstone falls both below the upper range and, where applicable, the upper tolerance interval of the respective analyte in weathered claystone. This implies that the chemical results of weathered sandstone fall within the expected distribution of chemical results of weathered claystone.

TABLE 4-42

BACKGROUND TOTAL METAL RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	Ag	Al	As	Ba	Be	Ca	Co	Cr	Cu	Fe	Hg	Li	Mg	Mn	Mo	Ni	Pb	Sr	Sn	V	Zn
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
NUMBER DETECTS	1	4	3	3	3	4	1	4	3	4	2	4	3	4	4	2	4	3	1	3	4
PERCENT DETECTS	25	100	75	75	75	100	25	100	75	100	50	100	75	100	100	50	100	75	25	75	100
MAX. VALUE	12.7	10300	3.6	165	2.2	5940	20.5	10.7	19.6	12300	0.27	7.0	2520	305	11.2	14.3	13.4	69.2	268	22.2	79.9
MIN. VALUE	12.7	2470	2.3	47.2	1.7	2310	20.5	3.9	8.1	3040	0.12	2.6	1290	14.9	4.3	10.6	9.4	47.2	268	11.5	38.1
*MEAN	---	5335	2.74	78.89	1.74	3673	---	6.63	9.53	7643	0.11	4.70	1511.1	119.83	7.075	9.57	11.400	47.89	---	14.46	52.75
*STD. DEVIATION	---	3071	0.77	59.92	0.51	1383	---	2.73	6.62	3277	0.11	1.77	657.91	111.81	2.56	3.49	1.42	22.39	---	5.31	16.48
COEFF./VARIATION	---	.5756	.2810	.7595	.2931	.3765	---	.4118	.6946	.4288	1.0	0.3766	0.4354	0.9331	0.3618	0.3647	0.1246	0.4675	---	0.3672	0.3124
MAX DET. LIMIT	2.4	---	2.2	47.9	1.2	---	12.0	---	6.0	---	0.12	---	1200	---	---	9.6	---	23.9	23.9	12.0	---
MIN DET. LIMIT	2.1	---	2.2	47.9	1.2	---	10.7	---	6.0	---	0.11	---	1200	---	---	9.2	---	23.9	21.3	12.0	---
APP. STAT. METHOD	TP	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	TP	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	TP	ANOVA	ANOVA
*T.INTERVAL(U.LIMIT)	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MEAN+3 STD. DEV.	---	14548	5.05	259.7	3.27	7822	---	9.36	29.4	17474	44	10.0	3485	455.26	14.75	20.04	15.66	115.1	---	30.39	102.2

Notes: Total Metals not detected in Background Borehole Sandstone: Sb,Cd,Cs,K,Se,Na,Tl

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-43

OTHER BACKGROUND INORGANIC RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS REPORTED IN mg/kg)

	SULFIDE	NITRATE	pH
NUMBER OF SAMPLES	4	4	4
NUMBER DETECTS	1	3	4
PERCENT DETECTS	25	75	100
MAX. VALUE	2	1.9	9.2
MIN. VALUE	2	1.2	8.0
*MEAN	---	1.31	8.675
*STD. DEVIATION	---	0.39	0.44
COEFF./VARIATION	---	0.2977	0.0507
MAX DET. LIMIT	3	1.1	---
MIN DET. LIMIT	2	1.1	---
APP. STAT. METHOD	TP	ANOVA	ANOVA
**T.INTERVAL(L.LIMIT)	---	---	---
*T.INTERVAL (U.LIMIT)	---	---	---
MEAN + 3 STD. DEV.	---	2.48	9.995
MEAN - 3 STD. DEVIATI			7.355

Notes:

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

**Lower Tolerance Intervals reported for two-sided parameters.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

TABLE 4-44

BACKGROUND TOTAL RADIOCHEMICAL RESULTS

WEATHERED SANDSTONE

(CONCENTRATIONS IN pCi/gm) (pCi/ml FOR TRITIUM)

	ALPHA	BETA	U233,U234	U235	U238	Sr89,Sr90	Pu239,Pu240	Am241	Cs137	TRITIUM	Ra226	Ra228
NUMBER OF SAMPLES	4	4	4	4	4	4	4	4	4	4	2	2
NUMBER DETECTS	4	4	4	4	4	4	4	0	4	4	2	2
PERCENT DETECTS	100	100	100	100	100	100	100	---	100	100	100	100
MAX. VALUE	37+/-17	29+/-6	0.8+/-0.3	0.1+/-0.1	1.0+/-0.2	0.4+/-0.6	0.01+/-0.01	---	0.0+/-0.1	0.39+/-0.15	1.0+/-0.1	1.1+/-0.2
MIN. VALUE	19+/-13	20+/-5	0.5+/-0.1	0.0+/-0.1	0.6+/-0.2	-0.7+/-1.0	-0.01+/-0.01	---	0.0+/-0.1	0.00+/-0.15	0.9+/-0.1	1.0+/-0.2
*MEAN	27.000	25.750	0.600	0.025	0.775	-0.175	0.000	---	0.000	0.105	0.950	1.050
*STD. DEVIATION	7.0356	3.6997	0.1225	0.0433	0.1479	0.3961	0.0071	---	0.000	0.1647	0.9513	1.0512
COEFF./VARIATION	0.2606	0.1437	0.2041	1.7321*	0.1908	-2.2633*	---	---	---	1.5685*	1.0014*	1.0011*
APP. STAT. METHOD	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	ANOVA	---	ANOVA	ANOVA	ANOVA	ANOVA
MAX DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
MIN DET. LIMIT	---	---	---	---	---	---	---	---	---	---	---	---
*T.INTERVAL(U. LIMIT)	---	---	---	---	---	---	---	---	---	---	---	---
MEAN + 3 STD. DEV.	48.1069	36.8490	0.9674	0.1549	1.2187	1.0132	0.0212	---	0.0000	0.5991	3.8039	4.2036

Notes: Because of results on other radionuclides, Radium 226 and Radium 228 were not run on all background borehole samples.

*Tolerance Intervals, Coefficient of Variation, Mean, and Standard Deviation not calculated when % detects < 50.

*Tolerance Intervals not calculated when number of samples is less than 7.

***Lognormal Tolerance Interval may be appropriate.

Key to Statistical Methods: TIN - Tolerance Interval based on Normal Distribution

TP - Test of Proportions. Note that this test requires the total (background & nonbackground) detects >= 5.

TIP - Tolerance Interval based on Poisson Distribution

ANOVA - Analysis of Variance

SECTION 5.0

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APPENDIX E
SELECTED EXCERPTS, 1988 ANNUAL RCRA GROUNDWATER MONITORING REPORT FOR REGULATED UNITS AT ROCKY FLATS PLANT

1988 ANNUAL RCRA GROUND-WATER MONITORING REPORT FOR REGULATED UNITS AT ROCKY FLATS PLANT

1 March 1989

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APPENDICES

1.0 INTRODUCTION

This report presents 1988 ground-water monitoring data as required under the Colorado Hazardous Waste Act regulations, 6 CCR 1007-3, Subpart F, 265.94 for RCRA interim status units at Rocky Flats Plant. The referenced regulations apply to the interim status regulated units undergoing closure at the Plant. These units include the Solar Evaporation Ponds, Present Landfill, West Spray Field, and the Original Process Waste Line. An assessment monitoring program is ongoing at the Solar Evaporation Ponds in accordance with 6 CCR 1007-3 and 40 CFR Parts 265.93(d), and alternate monitoring programs are being conducted at the Present Landfill, West Spray Field, and Original Process Waste Line pursuant to 6 CCR 1007-3 and 40 CFR Part 265.90(d).

Revised Closure Plans for the Solar Evaporation Ponds and Present Landfill were submitted to the U. S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) on 1 July 1988, and Revised Closure Plans for the West Spray Field and Original Process Waste Lines were submitted to EPA and CDH on 5 October 1988 as part of the Revised RCRA Post-Closure Care Permit Application (U.S. DOE, 1988). Appended to each of these revised closure plans is a hydrogeologic characterization report. These reports present additional results of 1986, 1987, and 1988 ground-water investigations at these four sites. Each report also contains recommendations for field work to further characterize the hydrogeologic setting at each regulated unit.

Section E (Ground-water Monitoring and Protection) of the Revised Post-Closure Care Permit Application (U.S. DOE, 1988) addresses the ground-water monitoring requirements of 6 CCR 1007-3, Part 265, Subpart F, for interim status monitoring and 6 CCR 1007-3, Part 264, Subpart F, for the post-closure care period for regulated units. Presented in Section E are results of interim status monitoring at that time and plans for continued interim status monitoring. Also presented are descriptions of the uppermost aquifer and contaminant plumes based on data available at that time.

1.1 GROUND-WATER MONITORING AT ROCKY FLATS PLANT

Ground-water monitoring for radionuclides and other parameters has been conducted at Rocky Flats Plant since the first monitoring wells were installed in 1960. A total of 56 wells were installed at the Plant between 1960 and 1985. These wells were routinely sampled for radionuclides, and beginning in 1985, they were sampled for other chemical parameters (volatile organics, metals, and inorganics). There are no well completion data for any of the wells installed prior to 1986.

In late 1986, Phase I of a comprehensive program of site characterizations, remedial investigations, feasibility studies, and remedial/corrective actions began at the Rocky Flats Plant. These investigations were pursuant to the U.S. Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) and a Compliance Agreement finalized by representatives of the DOE, the EPA, and the CDH on 31 July 1986. CEARP is now known as the Environmental Restoration (ER) Program.

Sixty-nine (69) monitoring wells were installed in 1986 to characterize the hydrogeology and ground-water quality of the entire Plant and to satisfy RCRA Subpart F requirements. The work plan for installation, sampling, and analysis of these wells is presented in the Geological and Hydrological Site Characterization

Draft Work Plan for Rocky Flats Plant (Rockwell International, 1986a). Site characterization and plume delineation wells were installed at the Solar Evaporation Ponds (assessment monitoring program), and site characterization wells were constructed at the West Spray Field and Present Landfill (alternate monitoring programs) as part of the Plant-wide characterization program.

Phase I investigations included:

1) detailed characterization of ground-water flow and quality in the vicinity of the solar evaporation ponds;
2) preparation of the ground-water monitoring and protection section of the Rocky Flats Plant RCRA Part B permit application (Rockwell International, 1986b);
3) preparation of closure plans for the West Spray Field, Present Landfill, and Solar Evaporation Ponds; and
4) preparation of a RCRA Post-Closure Care Permit Application for regulated units undergoing closure.

An additional 67 wells were installed at Rocky Flats Plant in 1987 to characterize ground-water quality and flow at various Solid Waste Management Units (SWMUs) and at the RCRA regulated units. The designation, Solid Waste Management Unit, is equivalent to the term CERCLA site. This equivalency applies to all SWMUs other than the regulated units. The work plans for installation, sampling, and analysis of these wells are presented in the CEARP Installation Generic and Site Specific (Remedial Investigation) Work Plans (U.S. DOE, 1987a and U.S. DOE, 1987b).

Quarterly sampling of monitoring wells at Rocky Flats Plant is initiated immediately upon their completion and development. In general, the 1986 wells were sampled once during 1986 and quarterly during 1987 and 1988. The 1987 wells were sampled once during 1987 and quarterly during 1988. Water levels are measured monthly as well as at the time of sampling. The unconfined water table in surficial materials at Rocky Flats Plant is dynamic; thus, some wells are dry upon inspection for quarterly sampling, and no sample is collected.

Ground-water samples are analyzed for the parameters listed in Table 1. During 1986 ground-water samples were analyzed for HSL volatiles, semi-volatiles, and metals as well as major ions and radionuclides. In 1987 and 1988 analyses were performed by an on-site Rockwell International laboratory. During the first three quarters of 1987, the volatile organic analyte list was reduced to the nine volatile compounds previously detected in ground water at the Plant. Ground-water sample analytes consisted of nine volatile organic compounds, dissolved metals, major ions, and dissolved radionuclides (Table 1). During the fourth quarter of 1987, the Rockwell laboratory obtained a gas chromatograph/mass spectrometer and began analyzing for Hazardous Substances List (HSL) volatile organic compounds.

Again, due to the dynamic nature of the unconfined water table at the Plant, there was sometimes insufficient water in wells to analyze for the entire parameter list. Samples are collected in the following order when this situation occurs:

- Volatile Organic Compounds;
- Plutonium, Uranium, and Americium;
- Nitrate;
- Metals;
- Other Major Ions; and
- Other Radionuclides.

Sampling and analysis records are maintained quarterly in compliance with 6 CCR 1007-3 and 40 CFR 265.94(b). An annual report was compiled in March, 1988, which described ground-water elevations, ground-water migration rates, and included the results of the ground-water sample analyses for 1987 (Rockwell International, 1988).

1.2 PURPOSE AND SCOPE

This report presents interim status 1988 quarterly ground-water monitoring results for the Solar Evaporation Ponds, Present Landfill, and West Spray Field in accordance with 6 CCR 1007-3, Part 265.94. Included are analytical ground-water quality data for the first through fourth quarters of 1988 (Appendices F through I) and an evaluation of these data in accordance with 6 CCR 1007-3, Part 264.94(b). Of the radionuclide results, only tritium data are available from the laboratory for third and fourth quarter 1988. Also, metals analyzed by atomic absorption spectrophotometry were not available for fourth quarter 1988, and volatile organic laboratory blank data for first through fourth quarters 1988 are currently not available. As not all data are available for report submission, an addendum will be submitted at a later date providing all the 1988 data and revised interpretation of the data if so warranted.

Plans for an Original Process Waste Line interim status alternate monitoring system are presented in Section E of the Post-Closure Care Permit Application (U.S. DOE, 1988). Although these investigations have begun, there are insufficient data at this time for a report submittal. Therefore, the Original Process Waste Line regulated unit is not addressed in this report.

1.3 GROUND-WATER QUALITY ASSESSMENT APPROACH

1.3.1 Interpretation of Uppermost Aquifer

Aquifer and uppermost aquifer are specifically defined in the RCRA regulations. An aquifer "means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs". The uppermost aquifer "means the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary". Because there are many water bearing units at the Rocky Flats Plant, it is necessary that these definitions be interpreted for development of practical ground-water monitoring systems which are in keeping with the intent of the Subpart F ground-water protection regulations.

The water bearing units at the Rocky Flats Plant consist of alluvium, colluvium, valley fill alluvium, and sandstones and weathered and unweathered claystones of the Laramie and Arapahoe Formations. The alluvium, colluvium, and valley fill alluvium fit the RCRA definition of the uppermost aquifer based on their proximity to the ground surface and high hydraulic conductivities relative to the other units. Conversely, the unweathered claystone is not an aquifer because of its low hydraulic conductivity (generally on the order of 1×10^{-7} to 1×10^{-8} centimeters per second [cm/sec]). This leaves for interpretation whether sandstones and weathered claystones, which are hydraulically interconnected with the alluvial systems, are a part of the uppermost aquifer. In some locations weathered claystones and sandstones exhibit hydraulic conductivities similar to the unweathered claystone and therefore should not be considered a part of the uppermost aquifer. However, because hydraulic conductivities for these units vary across the Plant site, and in some instances these units crop out beneath the regulated units, weathered claystones and sandstones will be considered part of the uppermost aquifer when:

1) they crop out beneath the regulated unit, or
2) they subcrop in saturated surficial materials that have been contaminated by the regulated unit, regardless of location with respect to the regulated unit.

The above interpretation of the uppermost aquifer provides the basis for the ground-water monitoring systems described in this report for detecting releases at the point of compliance, and plume characterization.

1.3.2 Ground-Water Quality Assessment

For assessment and alternate ground-water monitoring programs, the operator is required, at the minimum, to determine:

1) whether hazardous waste or hazardous waste constituents have entered the ground water;
2) the rate and extent of migration of the hazardous waste or hazardous waste constituents in the ground water; and
3) the concentrations of the hazardous waste or hazardous waste constituents in the ground water (6 CCR 1007-3 265.93 (a), 40 CFR 265.93(d)(4)).

The 1988 results of this assessment are the subject of this annual report. Hazardous constituents are identified in Appendix IX (52 FR 25947). Because inorganic hazardous constituents occur naturally in ground water, only those that are above apparent background levels are discussed and evaluated as potential site contaminants. Also included is a discussion of listed non-Appendix IX constituents (Table 1, 52 FR 25944). These constituents, which are primarily major ions, are also potential site contaminants. Lastly, radionuclides are discussed and evaluated as potential site contaminants if concentrations are above apparent background levels.

The term apparent background levels is used because at the time of this evaluation a thorough characterization of background ground-water chemistry was not available. A plan for background characterization has been prepared (Rockwell International, 1989) and is currently being implemented. For this evaluation, data from alluvial well 55-86 and bedrock well 54-86 (Plate I) have been used to establish the upper limit of the background range for inorganic constituents in alluvial and bedrock ground water, respectively (Appendix A). These wells are upgradient of all known Solid Waste Management Units (SWMUs). Data available from quarterly monitoring in 1987 and 1988 were used to establish the limits shown in Table 2.

Also shown in Table 2 are proposed concentration limits for these constituents. Although "proposed concentration limits" is a term applicable only to permitted facilities, the significance, in terms of protection of human health and the environment, of constituents above apparent background levels is discussed in this report based on these limits. The basis for these limits is discussed below.

The ground-water protection standards established in 6 CCR 1007-3 264.94 (40 CFR 264.94) for hazardous constituents are based on either background levels or the Safe Drinking Water Act (SDWA) primary drinking water standards for SDWA metals. It should be noted that background levels are only estimates and subject to change once background characterization has been completed. Alternate concentration limits may be established if approved by the Regional Administrator.

Concentration limits may be established for non-Appendix IX constituents where necessary to protect human health and the environment. These are the Federal Register, Table 1 constituents (52 FR 25944). Concentration limits are also proposed for other nonhazardous constituents and radionuclides.

Since two reservoirs are located downgradient of the Plant, drinking water and human health standards are considered primary when setting concentration limits for hazardous and nonhazardous constituents. The ground-water protection standard in 6 CCR 1007-3 264.94 (40 CFR 264.94) is used for the SDWA metals specified (standards equivalent to the SDWA drinking water standards). The major ions and non-Appendix IX metals have concentration limits set by the Colorado Department of Health (CDH) as ground-water standards for the protection of human health, or for the protection of agriculture if human health standards have not been established. For non-SDWA Appendix IX metals where no standards have been established, apparent background water quality for Rocky Flats Plant is used.

The limits for radionuclides have been taken from a variety of sources. The plutonium and americium limits are the proposed drinking water standards for these compounds (51 FR 34859). The uranium limit is a CDH surface water standard (5 CCR 1002-8, Sec. 3.8.5 (3)). The other radionuclide limits are the SDWA maximum contaminant levels.

4.0 GROUND-WATER MONITORING AT THE PRESENT LANDFILL

The Present Landfill is located on the western end of an unnamed tributary to North Walnut Creek. The landfill was placed in operation on August 14, 1968, after a study determined that a landfill operation would be the most efficient and economical means to dispose of the Plant's solid waste. A number of available sites within the Plant boundaries were evaluated, and the site at the west end of the North Walnut Creek unnamed tributary was selected. The drainage was filled with five feet of soil borrowed from on-site. Aerial photographs from August, 1969, show that landfill operations had commenced by that time.

Currently, the landfill is accepting nonhazardous solid waste at a rate of approximately 115 cubic yards per workday. Records indicate some hazardous waste was disposed at the landfill, rendering it a RCRA-regulated unit. However, hazardous constituent disposal in the landfill was eliminated in November 1986. Solid wastes will no longer be accepted at the landfill after June 1, 1989. As of July 1988, the landfill covered approximately 765,000 square feet of land. In order to reduce wind dispersion and infiltration, approximately three feet of compacted soil has been placed on top of the waste in areas where disposal is no longer occurring.

Sometime after the Present Landfill went into operation in 1968, excess water from the landfill pond was pumped atop a ridge south of the pond. The sprayed water collected on the roadway and flowed into North Walnut Creek. The spraying was moved north of the landfill pond adjacent to the irrigation ditch (SWMU 167.1, Figure 16) when this was discovered. The spray water then collected in local drainage channels and flowed around the landfill pond to the main drainage. The spraying was again moved. The final location was south of the west end of the landfill pond adjacent to the pond. The excess spray water flowed back into the landfill pond.

The landfill will be closed in accordance with the closure plan presented in the Post-Closure Care Permit Application for Rocky Flats Plant (U.S. DOE, 1988). Post-closure inspection, maintenance, and monitoring of the Present Landfill will be performed in accordance with 6 CCR 1007-3 Part 264 (40 CFR Part 264).

4.1 SUMMARY OF PREVIOUS INVESTIGATIONS

Pursuant to 6 CCR 1007-3 and 40 CFR 265.90(d), a specific plan for the installation, maintenance, and operation of the alternate ground-water monitoring system at the Present Landfill was submitted to CDH and EPA. The submitted plan, Comprehensive Environmental Assessment and Response Program (CEARP) Phase 2 Site Specific Monitoring Plan (U.S. DOE, 1987), included a plan for the installation and quarterly sampling, and analysis of upgradient and downgradient wells. The plan also included the procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain of custody control.

Two alluvial wells (7-86 and 10-86) and two bedrock wells (8-86 and 9-86) were installed at the Present Landfill as part of Plant-wide hydrogeologic site investigations in 1986. Three additional wells (alluvial wells 40-87 and 42-87 and bedrock well 41-87BR) were installed in and around the landfill in 1987 according to the CEARP Phase 2 Site Specific Monitoring Plan. Alluvial wells 58-87, 59-87, 60-87, 61-87, 62-87, 63-87, 64-87, 65-87, 66-87, 67-87, 68-87, 60-87, and 72-87 were completed in and around the landfill to evaluate the performance of the ground-water intercept system and the slurry wall (Figure 16).

Quarterly monitoring of wells at the landfill was initiated immediately upon their completion and development. The 1986 wells were sampled once during 1986 and quarterly during 1987 and 1988. The 1987 wells were sampled once during 1987 and quarterly during 1988. Ground-water samples are analyzed for the parameters listed in Table 1 as discussed in Section 1.1. Water levels are measured monthly as well as at the time of sampling.

4.1.1 Nature and Extent of Ground-water Contamination

Results of hydrogeologic investigations of the Present Landfill suggest that the ground-water intercept system may not completely isolate the landfill from the surrounding ground-water. Based upon an examination of alluvial water quality data from wells within and surrounding the landfill it appeared the landfill contributes calcium, bicarbonate, and to a lesser extent sodium, sulfate, iron, manganese, and strontium to the ground water. Ground water to the north of the north slurry wall had similar concentrations of these analytes, which may be due to the historical spray irrigation operation, north and upgradient of this location. With respect to the public health significance of the water quality directly downgradient of the landfill (well 42-87), only iron and manganese exceeded the proposed concentration limits. However, manganese also exceeds the limit (maximum concentration of 0.63 mg/l) in upgradient ground water, and it was not elevated downgradient with respect to upgradient conditions. High salt concentrations further down the drainage (wells 6-86 and 5-86) appear to result from another yet unidentified and presumably natural source.

Bedrock ground-water quality appears to be largely influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial ground water within the landfill.

4.2 UPPERMOST AQUIFER

The uppermost aquifer in the Present Landfill Area is comprised of the saturated surficial materials. Rocky Flats Alluvium and disturbed ground occur upgradient of and within the landfill; colluvium and North Walnut Creek valley fill alluvium are present downgradient of the Present Landfill.

In addition, the uppermost aquifer includes weathered claystones of the Arapahoe Formation which crop out or subcrop beneath the surficial materials within the waste management area. At present, there are limited data on the extent of saturation and hydraulic conductivity of weathered claystones at the Present Landfill. However, weathered claystone is included within the definition of the uppermost aquifer because these portions of the Arapahoe Formation are more permeable than unweathered bedrock, and they are in direct contact with the saturated surficial materials within the waste management unit. The depth of weathering varies within the claystone subcropping under this waste management area. Table 23 lists the depth of weathering for monitoring wells within the waste management unit.

Arapahoe sandstones which potentially crop out or subcrop beneath saturated surficial materials within the waste management unit of the Present Landfill have been encountered in wells 65-87, 8-86, 41-87, 64-87BR, and 70-87 (Figure 16). These sandstones are also included as part of the uppermost aquifer. Each subcropping Arapahoe sandstone which is included in the uppermost aquifer based on the above criteria will be considered part of the uppermost aquifer to such depth where the sandstone pinches out.

Unweathered claystone is not considered a part of the uppermost aquifer because of its low hydraulic conductivity. Arapahoe sandstones which do not subcrop beneath the surficial materials of the waste management unit are not considered a part of the overlying aquifer because of the low hydraulic conductivity claystone separating these sandstones from surficial materials.

Hydraulic conductivity data for the Present Landfill area are listed in Tables 24, 25, and 26. The geometric mean for Rocky Flats Alluvium varies from 1.8×10^{-5} cm/s for drawdown/recovery tests to 4.6×10^{-4} cm/s for slug tests. These values are two to three orders of magnitude in excess of the geometric mean for the unweathered claystone of the Arapahoe Formation at the Present Landfill, 6.2×10^{-7} cm/s. Although Arapahoe sandstones exhibit conductivities similar to the unweathered claystone, they will be included in the definition of the uppermost aquifer if they subcrop within the waste management unit.

4.3 GROUND-WATER FLOW DIRECTIONS

In order to control ground-water flow around the landfill, a two-part leachate and ground-water collection system was constructed in 1974 (Figure 16). This system was designed to collect and divert ground water around the outside of the landfill and to collect leachate generated in the landfill. The ground-water collection portion of the system is located on the exterior of the excavation and is separated from the leachate collection portion of the system by a 4.5-foot wide zone of clayey soil.

Field reconnaissance and a review of the borehole logs, topographic maps, and previous reports have shown that the landfill wastes bury the leachate collection system and extend beyond the system. Therefore, leachate generated outside the landfill trench would be collected by the ground-water diversion system. In addition, the clay cutoff wall no longer extends to the surface of the landfill; this would allow ground water to flow across the clay cutoff wall if the water table elevation increases.

Along the eastern end of the landfill, slurry trenches have been emplaced (Figure 16). These trenches may also be influencing ground-water flow; future pumping tests are planned to evaluate the effectiveness of the slurry trenches as hydraulic barriers.

The following conclusions regarding the effectiveness of the leachate/ground-water intercept system have been made based on water level and ground-water quality data (U.S. DOE, 1988).

1) The ground-water intercept system is diverting ground water away from the west end of the landfill.

2) The ground-water intercept system is not diverting ground water away from the north and south sides of the landfill.

3) The clay barrier is holding ground water in the landfill along the west and north sides.

4) The clay barrier is ineffective on the south side of the landfill and is allowing contaminated ground water to leave the landfill at times.

5) The leachate collection system appears to function intermittently on the north side of the landfill.

In general, ground water flows eastwardly in surficial materials toward the landfill pond. This general pattern of ground-water flow is evidenced by the water table maps constructed for February, June, August, and November, 1988 (Figures 17 through 20, respectively).

Of the four months evaluated, November, 1988 appears to be the driest month (Figure 20). This is illustrated by four dry wells (7-86, 72-87, 40-87, and 42-87) and relatively lower water table elevations. In contrast, June 1988 appears to be the wettest month, with comparatively higher water table elevations and no dry wells (Figure 18).

4.4 GROUND-WATER CHEMISTRY AT THE LANDFILL

4.4.1 Alluvial Ground-water Quality

Tables 27, 28, 29, and 30 (summarized from ground-water quality data presented in Appendix D) show that alluvial ground water at the landfill appears to have elevated concentrations of barium, calcium, iron potassium, magnesium, manganese, sodium, strontium, zinc, bicarbonate, sulfate, nitrate, TDS, and uranium. However, well 10-86 is an upgradient alluvial well where ground water also has elevated levels of several of these constituents. This, in itself, suggests that background concentrations may be more variable than depicted for well 55-86 south and upgradient of the West Spray Field. Constituents elevated in ground water downgradient of the landfill that are not elevated in the immediate upgradient well include calcium, iron, potassium, magnesium, manganese (occasionally elevated in upgradient well), sodium, strontium, zinc, bicarbonate, and TDS. Typical of most sanitary landfills, the Present Landfill is observed to impact ground water quality through increased major ion, iron, manganese, and zinc concentrations. Strontium concentrations are also elevated. Manganese is the only constituent that is ubiquitous and that consistently exceeds the proposed concentration limit; however, it historically has been and still exceeds the limit in ground water at the upgradient well 10-86. As shown in Figures 21, 22, 23, 24, 25, and 26, landfill contaminants migrate with the flow directly toward the landfill pond and along the leachate collection systems toward the landfill pond.

Volatile organic contamination is of little significance. Only sporadic and low concentrations of methylene chloride, acetone, 1,1-DCA, $CHCl_3$, CCl_4, TCE, PCE, and toluene were present in samples during 1988. Carbon tetrachloride was not present in samples from 1987. Methylene chloride , chloroform and toluene were present in the upgradient well, 10-86. This suggest these contaminant concentrations may be due to laboratory artifact; however, an evaluation of laboratory blank data is needed to verify this assertion.

4.4.2 Downgradient Alluvial Ground-Water Quality

Wells 7-86, 40-87, 42-87, 6-86, and 5-86 are located progressively downgradient of the Present Landfill. Well 7-86 is usually dry and only organic chemistry data exist for this well. Well 40-87 is also dry. Well 42-87 was dry during the third and fourth quarter 1988. Analytes exceeding the estimated background range during the first quarter of 1988 include barium, calcium, iron, potassium, magnesium, manganese, sodium, strontium, sulfate, and TDS. Of these analytes, only iron (0.4 mg/l), and manganese (0.57 mg/l) exceed the proposed concentration limits. Iron was not above the proposed concentration limit in 1987, and as previously mentioned, manganese is above the limit in the upgradient well 10-86

As shown in Tables 28, 29, and 30, the concentrations of analytes at wells 6-86 and 5-86 do not indicate a release from the landfill. These high concentrations of constituents are not seen within the landfill ground water or immediately downgradient of the landfill (well 42-87), indicating that another source of high TDS water exists downgradient of the landfill. As no SWMUs are known to be located downgradient of the landfill, this source may be due to natural saline mineral dissolution. Because gross alpha (110 pCi/l), gross beta (54 pCi/l), and total uranium (169 pCi/l) exceed the proposed concentration limits at well 5-86, the source of this ground water will be investigated.

4.4.3 Bedrock Ground-water Quality

Three bedrock wells currently exist to monitor bedrock ground-water quality. Well 9-86 is located immediately west of the landfill; 8-86 is located immediately east of the landfill; and 41-87BR is downgradient of the landfill embankment in the unnamed tributary of North Walnut Creek. Tables 31, 32, 33, and 34 summarize above background inorganics, metals, radionuclides, and volatile organic concentrations during 1988. Ground-water quality data are presented in Appendix D.

Inspection of Tables 31, 32, and 33 indicates that bedrock ground water at the landfill has apparently elevated concentrations of barium, molybdenum, sodium, strontium, uranium, sulfate, and TDS. However, as with alluvial ground water in this vicinity, the upgradient bedrock ground water has apparent elevated concentrations of some of these constituents. At times, well 9-86 has had above background concentrations of barium, iron, zinc, mercury, sodium, nitrate, and sulfate, suggesting the background ranges for these constituents are higher than that depicted for well 54-86. Relative to ground water at well 9-86, ground water at well 8-86 is similar in composition. In contrast, ground water at well 41-87 is notably elevated in calcium, sodium, chloride, strontium, and TDS relative to well 9-86. Total uranium also was present at 7.4 pCi/l in the second quarter; however, uranium was not detected during the first quarter. The high concentrations of major ions and metals at 41-87 are not observed in alluvial ground water within, adjacent to, or immediately downgradient of the landfill. Although it is possible the sandstone in well 41-87 subcrops beneath the landfill, it is concluded that the quality of the ground water in this sandstone reflects dissolution of minerals within the sandstone and claystone.

As shown on Table 34, methylene chloride, chloroform, and toluene were detected in all fourth quarter 1988 bedrock ground-water samples for the Present Landfill. Methylene chloride was the only volatile organic compound detected in the third quarter samples, and volatile organics were undetected during first and second quarters 1988 in the landfill bedrock wells. These occurrences of volatile organic compounds are likely due to laboratory artifact; although laboratory blank data are currently not available.

4.5 CONTAMINANT MIGRATION RATES

Based on slug tests of wells completed within the landfill (wells 62-87 and 63-87), the hydraulic conductivity of landfill materials ranges from 6.2×10^{-4} cm/s to 6.7×10^{-4} cm/s (Table 24). Using the maximum hydraulic conductivity of 6.7×10^{-4} cm/s (694 ft/yr), an assumed effective porosity of 0.1, and a horizontal hydraulic gradient of 0.027 ft/ft, ground water within the landfill is moving at a rate of 185 ft/yr. Thus, approximately eight years are required for ground water in the west end of the landfill (well 59-86) to reach the landfill pond (1,500 feet). Although hydraulic conductivity values for wells 62-86 and 63-86 are quite similar, fill materials are presumably heterogeneous, and flow conditions no doubt vary considerably within the landfill.

Once ground water within the landfill discharges to the landfill pond, it is retained within the pond where it either evaporates directly from the pond or evaporates via spray irrigation onto the hillside north of the pond.

Alluvial ground water within the valley fill alluvium downgradient of the landfill pond (well 42-87) appears to be impacted by the landfill. Alluvial ground water from the landfill may reach the valley fill by flowing through the ground-water intercept system which can discharge to the unnamed tributary, or past releases may have occurred via the spray irrigation of landfill pond water north of the landfill at SWMU 167.1 (Figure 16).

There are no site-specific hydraulic conductivity data available for valley fill alluvium in the unnamed tributary of Walnut Creek. In addition, the alluvium is dry during portions of the year. Therefore, ground-water flow rates in the unnamed tributary valley fill alluvium cannot be characterized at this time.

4.6 CONCLUSIONS AND RECOMMENDATIONS

4.6.1 Conclusions

Hydrogeologic investigation results of the Present Landfill suggest that the ground-water intercept system may not completely isolate the landfill from ground water exterior to the waste management unit. Hydraulic assessments for specific areas on the west, north, and south sides of the ground-water intercept system indicate ground water does migrate into the landfill at the west or northwest and may be exiting the landfill on the southwest at times of the year. However, water balance calculations indicate ground-water inflow probably occurs around the landfill. The intersection of the ground-water intercept system and the slurry walls may be the location of this inflow.

Based upon an examination of alluvial water quality data from wells within and surrounding the landfill, it appears the landfill may be impacting downgradient ground water with major ions, manganese, and iron. This is typical of any sanitary landfill. Strontium and barium are also elevated downgradient of the landfill. Of these analytes, only manganese is consistently higher than the proposed concentration limit; however, manganese is also higher than this limit in upgradient alluvial ground water. High salt concentrations further down the drainage (wells 6-86 and 5-86) appear to result from another yet unidentified and presumably natural source.

Bedrock ground-water quality is conjectured to be influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial ground water within the landfill.

4.6.2 Recommendations

The current ground-water monitoring program at the Present Landfill has not detected a contaminant plume. However, ground-water monitoring at the Present Landfill will continue as alternate monitoring. Recommendations for additional monitoring wells at the Present Landfill are presented in the Hydrogeologic Characterization Report (U.S. DOE, 1988), and additional interim status monitoring wells are also proposed in Section E of the Post-Closure Care Permit Application (U.S.

DOE, 1988). Recommendations for proposed monitoring wells discussed below include the recommendations from both of these referenced documents.

Quarterly monitoring of the 21 existing wells upgradient, within, and downgradient of the Present Landfill will continue. Fifteen additional monitoring wells are also proposed in and around the Present Landfill to further define the extent of saturation and the ground-water quality in surficial materials, weathered claystone bedrock, and subcropping sandstones. Slug tests will be conducted in all newly installed wells in addition to wells 40-87 and 42-87 to obtain additional hydraulic conductivity data for various materials at the landfill. Proposed well locations are shown on Figure 27, and additional well construction details are presented in Table 35.

Five new alluvial wells are proposed at the Present Landfill. Well LF-01 will effectively replace well 59-86. The Hydrogeologic Characterization Report (U.S. DOE, 1988) recommends that this well be replaced, as it penetrates the clay surface seal of the ground-water/leachate collection system. Proposed alluvial wells LF-07, LF-10, and LF-14 will be installed south, southeast, and north, respectively of the waste management area to monitor ground water potentially exiting the landfill via Rocky Flats Alluvium. Proposed alluvial well LF-04 will be constructed inside the south slurry wall opposite existing well 72-87. This well will be used to evaluate the effectiveness of the south slurry wall.

Three bedrock wells will be installed around the Present Landfill to assess the extent of saturation within the weathered claystone. Well LF-08 will be located on the south side of the landfill adjacent to proposed alluvial well LF-07; well LF-11 will be located east of the landfill pond adjacent to existing wells 40-87 and 41-87BR;

and well LF-15 will be completed in weathered claystone adjacent to proposed alluvial well LF-14.

Seven additional bedrock wells are proposed for monitoring subcropping sandstones at the Present Landfill. Wells LF-02 and LF-03 will monitor the sandstone which subcrops at existing wells 64-87 and 65-87, and wells LF-05 and LF-06 will be installed in the sandstone which subcrops at existing well 72-87. Proposed well LF-09 will be completed in the sandstone subcrop predicted beneath the landfill pond. The remaining two proposed bedrock wells, LF-12 and LF-13 will be completed in the upper and middle sandstones, respectively, encountered in existing well 41-87BR.

An impermeable cap will be placed on the Present Landfill area during closure to eliminate precipitation infiltration. This cap will aid in removing water currently present by reducing recharge to the landfill. However, the effectiveness of this plan is dependent upon the ability of the in-place ground-water collection system to effectively divert ground water away from the landfill. Therefore, single hole pump tests will be conducted in wells 63-87, 64-87, and the replacement well for 59-87 with wells 62-87, 65-87, and 58-87 serving as the observation wells, respectively. These tests will serve to establish if a hydraulic connection exists between alluvial ground water inside and outside the landfill at these locations.

Alluvial ground-water quality near wells 5-86 and 6-86 will be further investigated in order to determine the source and extent of the high TDS water.

5.0 REFERENCES

Rockwell International, 1986b, Resource Conservation and Recovery Act Part B - Operating Permit Application for U.S. DOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes: U.S. Department of Energy, unnumbered report.

Rockwell International, 1986a, Draft Work Plan, Geological and Hydrological Site Characterization; U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado, July 21, 1986.

Rockwell International, 1988, Ground-water Monitoring at Regulated Units, Rocky Flats Plant, Golden, Colorado, March 31, 1988.

Rockwell International, 1989, Background Hydrogeochemical Characterization and Monitoring Plan, Environmental Restoration Program, Rocky Flats Plant, January, 1989.

U.S. DOE, 1987a, Comprehensive Environmental Assessment and Response Program Phase 2: Rocky Flats Plant, Draft Installation Generic Monitoring Plan: U.S. Department of Energy.

U.S. DOE, 1987b, Comprehensive Environmental Assessment and Response Program Phase 2: Rocky Flats Plant, Draft Site Specific Monitoring Plan for High Priority Site: U.S. Department of Energy.

U.S. DOE, 1988, Resource Conservation and Recovery Act Post-Closure Care Permit Application for U.S. DOE Rocky Flats Plant Hazardous and Mixed Wastes, October 5, 1988.

APPENDIX E-4

PRESENT LANDFILL
ALLUVIAL GROUND-WATER LEVEL DATA

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **5-86**
SURFACE ELEVATION: 5720.07 FEET
ELEVATION - TOP OF CASING (TOC): 5722.61 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
September	8	1986	DRY	
October	13	1986	DRY	
November	26	1986	DRY	
January	1	1987	11.19	5711.42
February	1	1987	9.52	5713.09
April	1	1987	2.88	5719.73
May	7	1987	4.10	5718.51
June	1	1987	6.98	5715.63
July	8	1987	6.75	5715.86
July	30	1987	8.90	5713.71
August	3	1987	11.40	5711.21
September	28	1987	10.20	5712.41
November	3	1987	10.30	5712.31
December	8	1987	10.50	5712.11
January	6	1988	10.50	5712.11
February	24	1988	6.60	5716.01
March	14	1988	4.90	5717.71
April	11	1988	4.70	5717.91
May	12	1988	7.90	5714.71
June		1988	9.00	5713.61
July		1988	9.70	5712.91
August		1988	9.90	5712.71
September		1988	10.40	5712.21
October		1988	10.50	5712.11
November		1988	10.80	5711.81
December		1988	10.80	5711.81

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **6-86**
SURFACE ELEVATION: 5806.10 FEET
ELEVATION - TOP OF CASING (TOC): 5808.58 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
October	13	1986	11.13	5797.45
November	26	1986	10.99	5797.59
January	1	1987	10.92	5797.66
February	1	1987	10.83	5797.75
April	1	1987	3.29	5805.29
May	7	1987	3.88	5804.70
June	1	1987	7.22	5801.36
July	8	1987	9.20	5799.38
August	3	1987	8.90	5799.68
August	10	1987	8.60	5799.98
September	28	1987	9.70	5798.88
November	3	1987	9.70	5798.88
December	8	1987	9.70	5798.88
January	6	1988	3.30	5805.28
February	4	1988	10.20	5798.38
March	14	1988	10.10	5798.48
April	11	1988	4.50	5804.08
May	12	1988	5.40	5803.18
June		1988	7.90	5800.68
July		1988	8.00	5800.58
August		1988	8.20	5800.38
September		1988	8.70	5799.88
October		1988	8.90	5799.68
November		1988	9.30	5799.28
December		1988	9.30	5799.28

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: 7-86
SURFACE ELEVATION: 5924.46 FEET
ELEVATION - TOP OF CASING (TOC): 5926.52 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
September	29	1986	DRY	
October	13	1986	DRY	
November	26	1986	7.10	5919.42
January	1	1987	6.38	5920.14
February	1	1987	6.00	5920.52
April	1	1987	5.63	5920.89
May	6	1987	6.29	5920.23
June	1	1987	5.80	5920.72
July	8	1987	5.10	5921.42
August	4	1987	5.30	5921.22
August	10	1987	DRY	
August	31	1987	DRY	
September	28	1987	DRY	
November	3	1987	6.90	5919.62
December	8	1987	7.00	5919.52
January	6	1988	4.80	5921.72
February	4	1988	4.80	5921.72
March	21	1988	4.70	5921.82
April	11	1988	4.90	5921.62
May	12	1988	5.20	5921.32
June		1988	6.50	5920.02
July		1988	7.00	5919.52
August		1988	DRY	
September		1988	DRY	
October		1988	DRY	
November		1988	DRY	
December		1988	DRY	

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **10-86**
SURFACE ELEVATION: 5996.20 FEET
ELEVATION - TOP OF CASING (TOC): 5998.21 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
September	29	1986	10.35	5987.86
October	2	1986	11.53	5986.68
October	3	1986	12.71	5985.50
October	7	1986	10.30	5987.91
October	8	1986	14.43	5983.78
October	10	1986	16.90	5981.31
October	13	1986	14.09	5984.12
October	16	1986	13.59	5984.62
November	26	1986	11.56	5986.65
January	1	1987	12.19	5986.02
February	1	1987	9.56	5988.65
March	14	1987	9.50	5988.71
April	1	1987	2.90	5995.31
May	6	1987	2.44	5995.77
June	1	1987	4.71	5993.50
July	8	1987	5.50	5992.71
August	3	1987	8.60	5989.61
August	10	1987	9.10	5989.11
August	31	1987	9.70	5988.51
September	28	1987	11.70	5986.51
November	2	1987	13.00	5985.21
November	3	1987	13.00	5985.21
December	7	1987	13.50	5984.71
January	5	1988	13.50	5984.71
February	4	1988	11.60	5986.61
March	14	1988	9.50	5988.71
April	11	1988	8.70	5989.51
May	12	1988	10.20	5988.01
June		1988	8.70	5989.51
July		1988	9.70	5988.51
August		1988	10.50	5987.71
September		1988	12.50	5985.71
October		1988	13.00	5985.21
November		1988	13.70	5984.51
December		1988	14.40	5983.81

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **40-87**
SURFACE ELEVATION: 5882.69 FEET
ELEVATION - TOP OF CASING (TOC): 5884.69 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	6.20	5878.49
August	10	1987	DRY	
September	28	1987	DRY	
November	3	1987	8.00	5876.69
December	8	1987	8.00	5876.69
January	6	1988	7.60	5877.09
February	4	1988	7.50	5877.19
March	14	1988	6.20	5878.49
April	11	1988	5.30	5879.39
May	12	1988	4.40	5880.29
June		1988	7.20	5877.49
July		1988	6.80	5877.89
August		1988	7.20	5877.49
September		1988	DRY	
October		1988	DRY	
November		1988	DRY	
December		1988	DRY	

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **42-87**
SURFACE ELEVATION: 5854.05 FEET
ELEVATION - TOP OF CASING (TOC): 5855.93 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
August	10	1987	DRY	
September	28	1987	DRY	
November	4	1987	3.50	5852.43
December	8	1987	4.40	5851.53
January	6	1988	3.20	5852.73
February	4	1988	3.30	5852.63
March	14	1988	3.30	5852.63
April	11	1988	3.50	5852.43
May	12	1988	4.10	5851.83
June		1988	6.10	5849.83
July		1988	DRY	
August		1988	DRY	
September		1988	DRY	
October		1988	DRY	
November		1988	DRY	
December		1988	DRY	

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **58-87**
SURFACE ELEVATION: 5995.10 FEET
ELEVATION - TOP OF CASING (TOC): 5996.75 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	9.50	5987.25
January	5	1988	13.00	5983.75
February	4	1988	10.90	5985.85
March	14	1988	9.50	5987.25
April	11	1988	9.20	5987.55
June		1988	9.50	5987.25
July		1988	10.20	5986.55
August		1988	11.00	5985.75
September		1988	12.30	5984.45
October		1988	13.00	5983.75
November		1988	13.60	5983.15
December		1988	14.10	5982.65

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **59-87**
SURFACE ELEVATION: 5992.90 FEET
ELEVATION - TOP OF CASING (TOC): 5994.67 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	17.00	5977.67
January	5	1988	17.10	5977.57
February	4	1988	18.50	5976.17
March	14	1988	17.00	5977.67
April	11	1988	16.90	5977.77
May	12	1988	16.90	5977.77
June		1988	15.00	5979.67
July		1988	16.30	5978.37
August		1988	16.50	5978.17
September		1988	18.90	5975.77
October		1988	17.40	5977.27
November		1988	17.30	5977.37
December		1988	17.40	5977.27

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **60-87**
SURFACE ELEVATION: 5984.03 FEET
ELEVATION - TOP OF CASING (TOC): 5985.96 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	11.40	5974.56
January	5	1988	12.10	5973.86
February	4	1988	12.20	5973.76
March	14	1988	11.40	5974.56
April	11	1988	10.30	5975.66
May	12	1988	11.60	5974.36
June		1988	11.20	5974.76
July		1988	12.00	5973.96
August		1988	12.40	5973.56
September		1988	13.10	5972.86
October		1988	13.30	5972.66
November		1988	13.70	5972.26
December		1988	13.80	5972.16

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **61-87**
SURFACE ELEVATION: 5984.00 FEET
ELEVATION - TOP OF CASING (TOC): 5985.75 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	13.00	5972.75
February	4	1988	12.30	5973.45
March	21	1988	11.80	5973.95
April	11	1988	12.70	5973.05
May	12	1988	11.80	5973.95
June		1988	11.30	5974.45
July		1988	11.90	5973.85
August		1988	12.30	5973.45
September		1988	12.90	5972.85
October		1988	13.00	5972.75
November		1988	13.50	5972.25
December		1988	13.60	5972.15

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **62-87**
SURFACE ELEVATION: 5984.16 FEET
ELEVATION - TOP OF CASING (TOC): 5986.36 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	14.10	5972.26
February	4	1988	13.60	5972.76
March	21	1988	13.20	5973.16
April	11	1988	13.70	5972.66
May	12	1988	2.00	5984.36
June		1988	12.70	5973.66
July		1988	13.20	5973.16
July		1988	15.20	5971.16
August		1988	13.60	5972.76
September		1988	14.10	5972.26
October		1988	14.30	5972.06
October		1988	15.60	5970.76
November		1988	14.70	5971.66
November		1988	15.90	5970.46
December		1988	14.60	5971.76

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **63-87**
SURFACE ELEVATION: 5985.42 FEET
ELEVATION - TOP OF CASING (TOC): 5987.06 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	DRY	
February	4	1988	15.30	5971.76
March	21	1988	15.10	5971.96
April	11	1988	15.20	5971.86
May	12	1988	15.00	5972.06
June		1988	15.00	5972.06
August		1988	15.30	5971.76
September		1988	15.60	5971.46
December		1988	16.00	5971.06

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **64-87**
SURFACE ELEVATION: 5985.89 FEET
ELEVATION - TOP OF CASING (TOC): 5987.33 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
December	16	1987	9.00	5978.33
January	9	1988	7.50	5979.83
February	4	1988	17.60	5969.73
February	24	1988	6.90	5980.43
March	7	1988	6.80	5980.53
March	21	1988	17.90	5969.43
April	4	1988	6.70	5980.63
April	11	1988	18.20	5969.13
May	2	1988	6.90	5980.43
May	12	1988	18.40	5968.93
June		1988	17.10	5970.23
July		1988	17.10	5970.23
August		1988	17.40	5969.93
September		1988	20.80	5966.53
September		1988	13.60	5973.73
October		1988	19.20	5968.13
November		1988	19.70	5967.63
December		1988	19.70	5967.63

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **65-87**
SURFACE ELEVATION: 5983.08 FEET
ELEVATION - TOP OF CASING (TOC): 5985.02 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	14.50	5970.52
February	4	1988	13.20	5971.82
March	21	1988	13.10	5971.92
April	11	1988	12.40	5972.62
May	12	1988	13.00	5972.02
June		1988	12.40	5972.62
July		1988	12.80	5972.22
August		1988	13.20	5971.82
October		1988	14.30	5970.72
November		1988	15.30	5969.72
December		1988	15.30	5969.72

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **66-87**
SURFACE ELEVATION: 5981.90 FEET
ELEVATION - TOP OF CASING (TOC): 5983.64 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	11.50	5972.14
January	5	1988	13.00	5970.64
February	4	1988	11.90	5971.74
March	14	1988	11.50	5972.14
April	11	1988	10.90	5972.74
May	12	1988	11.70	5971.94
June		1988	11.00	5972.64
July		1988	11.50	5972.14
August		1988	11.90	5971.74
September		1988	12.30	5971.34
October		1988	12.90	5970.74
November		1988	13.90	5969.74
December		1988	14.00	5969.64

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **67-87**
SURFACE ELEVATION: 5969.50 FEET
ELEVATION - TOP OF CASING (TOC): 5971.72 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	4.30	5967.42
February	4	1988	10.40	5961.32
March	21	1988	10.00	5961.72
April	11	1988	9.90	5961.82
May	12	1988	10.10	5961.62
June		1988	10.20	5961.52
July		1988	10.70	5961.02
August		1988	11.00	5960.72
September		1988	11.50	5960.22
October		1988	11.50	5960.22
November		1988	11.70	5960.02
December		1988	11.70	5960.02

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **68-87**
SURFACE ELEVATION: 5968.48 FEET
ELEVATION - TOP OF CASING (TOC): 5970.31 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	9.80	5960.51
February	4	1988	9.10	5961.21
March	21	1988	8.80	5961.51
April	11	1988	8.20	5962.11
May	12	1988	8.80	5961.51
June		1988	8.80	5961.51
July		1988	9.40	5960.91
August		1988	9.70	5960.61
September		1988	10.20	5960.11
October		1988	10.10	5960.21
November		1988	10.40	5959.91
December		1988	10.40	5959.91

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **70-87**
SURFACE ELEVATION: 5966.30 FEET
ELEVATION - TOP OF CASING (TOC): 5968.35 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
January	6	1988	DRY	
February	4	1988	DRY	
March	21	1988	DRY	
April	11	1988	9.40	5958.95
May	12	1988	8.10	5960.25
June		1988	8.50	5959.85
July		1988	8.80	5959.55
August		1988	9.20	5959.15
October		1988	9.80	5958.55
November		1988	10.70	5957.65
December		1988	10.80	5957.55

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **71-87**
SURFACE ELEVATION: 5963.39 FEET
ELEVATION - TOP OF CASING (TOC): 5965.47 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	6.40	5959.07
January	5	1988	7.10	5958.37
February	4	1988	6.70	5958.77
March	14	1988	6.40	5959.07
April	11	1988	6.00	5959.47
May	12	1988	7.10	5958.37
June		1988	7.80	5957.67
July		1988	8.00	5957.47
August		1988	8.50	5956.97
September		1988	8.50	5956.97
October		1988	8.40	5957.07
November		1988	8.20	5957.27
December		1988	8.10	5957.37

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **72-87**
SURFACE ELEVATION: 5969.11 FEET
ELEVATION - TOP OF CASING (TOC): 5971.18 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	4.70	5966.48
January	6	1988	6.00	5965.18
February	4	1988	5.00	5966.18
March	14	1988	4.70	5966.48
April	11	1988	4.20	5966.98
May	12	1988	57.00	5914.18
June		1988	6.20	5964.98
July		1988	6.80	5964.38
August		1988	7.50	5963.68
September		1988	7.60	5963.58
October		1988	7.90	5963.28
November		1988	DRY	
December		1988	8.30	5962.88

APPENDIX E-5

PRESENT LANDFILL
BEDROCK GROUND-WATER LEVEL DATA

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **8-86**
SURFACE ELEVATION: 5925.03 FEET
ELEVATION - TOP OF CASING (TOC): 5926.83 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
November	10	1986	7.15	5919.68
November	12	1986	20.80	5906.03
November	13	1986	51.81	5875.02
November	26	1986	7.00	5919.83
January	1	1987	5.13	5921.70
February	1	1987	5.08	5921.75
April	1	1987	4.67	5922.16
May	6	1987	4.77	5922.06
June	1	1987	4.53	5922.30
July	8	1987	33.20	5893.63
August	4	1987	14.50	5912.33
August	11	1987	12.50	5914.33
August	31	1987	38.40	5888.43
September	28	1987	19.10	5907.73
November	3	1987	11.70	5915.13
December	8	1987	8.90	5917.93
January	6	1988	32.20	5894.63
February	4	1988	59.50	5867.33
March	21	1988	30.30	5896.53
April	11	1988	23.80	5903.03
May	12	1988	18.00	5908.83
June		1988	60.00	5866.83
July		1988	47.30	5879.53
August		1988	39.20	5887.63
September		1988	56.80	5870.03
October		1988	46.90	5879.93
November		1988	32.40	5894.43
December		1988	30.70	5896.13

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **9-86**
SURFACE ELEVATION: 5996.39 FEET
ELEVATION - TOP OF CASING (TOC): 5998.23 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
October	14	1986	69.30	5928.93
October	20	1986	84.14	5914.09
October	22	1986	119.91	5878.32
October	23	1986	128.81	5869.42
October	24	1986	126.94	5871.29
October	27	1986	116.63	5881.60
October	30	1986	116.12	5882.11
October	31	1986	128.24	5869.99
November	26	1986	62.56	5935.67
January	1	1987	30.13	5968.10
February	1	1987	28.75	5969.48
March	14	1987	30.60	5967.63
April	1	1987	27.60	5970.63
May	6	1987	27.04	5971.19
June	1	1987	43.10	5955.13
July	8	1987	43.90	5954.33
August	3	1987	31.70	5966.53
August	11	1987	30.80	5967.43
August	31	1987	41.90	5956.33
September	28	1987	31.40	5966.83
November	2	1987	29.40	5968.83
December	7	1987	28.60	5969.63
January	5	1988	28.20	5970.03
February	24	1988	37.00	5961.23
March	14	1988	30.60	5967.63
April	11	1988	28.80	5969.43
May	12	1988	28.20	5970.03
June		1988	45.10	5953.13
July		1988	31.30	5966.93
August		1988	29.40	5968.83
September		1988	68.90	5929.33
October		1988	34.10	5964.13
November		1988	29.70	5968.53
December		1988	28.60	5969.63

01/25/89

WATER LEVEL DATA
ROCKY FLATS PLANT

WELL NUMBER: **41-87**
SURFACE ELEVATION: 5882.78 FEET
ELEVATION - TOP OF CASING (TOC): 5884.55 FEET

MONTH/DAY MEASURED		YEAR MEASURED	DEPTH TOC TO WATER (FEET)	WATER ELEVATION (FEET)
March	14	1987	55.40	5829.15
September	28	1987	86.60	5797.95
November	4	1987	42.40	5842.15
December	8	1987	39.50	5845.05
January	6	1988	60.20	5824.35
February	4	1988	88.80	5795.75
March	14	1988	55.40	5829.15
April	11	1988	43.60	5840.95
May	12	1988	36.20	5848.35
June		1988	86.10	5798.45
July		1988	64.80	5819.75
August		1988	52.60	5831.95
September		1988	73.70	5810.85
October		1988	57.80	5826.75
November		1988	51.20	5833.35
December		1988	47.30	5837.25

APPENDIX F
SELECTED EXCERPTS, 1989 ANNUAL RCRA GROUNDWATER MONITORING REPORT FOR REGULATED UNITS AT ROCKY FLATS PLANT

1989 ANNUAL RCRA
GROUND-WATER MONITORING REPORT
FOR REGULATED UNITS AT
ROCKY FLATS PLANT

MARCH 1, 1990

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1.0 INTRODUCTION

This report presents 1989 ground-water monitoring data as required under the Colorado Hazardous Waste Act regulations, 6 CCR 1007-3, Subpart F, 265.94 for RCRA interim status units at Rocky Flats Plant. The referenced regulations apply to the interim status regulated units undergoing closure at the Plant. These units include the Solar Evaporation Ponds, Present Landfill, West Spray Field, and the Original Process Waste Lines. An assessment monitoring program is ongoing at the Solar Evaporation Ponds in accordance with 6 CCR 1007-3 and 40 CFR Parts 265.93(d), and alternate monitoring programs are being conducted at the Present Landfill, West Spray Field, and Original Process Waste Line pursuant to 6 CCR 1007-3 and 40 CFR Part 265.90(d).

Revised Closure Plans for the Solar Evaporation Ponds and Present Landfill were submitted to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) on 1 July 1988, and Revised Closure Plans for the West Spray Field and Original Process Waste Lines were submitted to EPA and CDH on 5 October 1988 as part of the Revised RCRA Post-Closure Care Permit Application (U.S. DOE, 1988a). Appended to each of these revised closure plans is a hydrogeologic characterization report. These reports present additional results of 1986, 1987, and 1988 ground-water investigations at these four sites. Each report also contains recommendations for field work to further characterize the hydrogeologic setting at each regulated unit.

Section E (Ground-water Monitoring and Protection) of the Revised Post-Closure Care Permit Application (U.S. DOE, 1988a) addresses the ground-water monitoring requirements of 6 CCR 1007-3, Part 265, Subpart F, for interim status monitoring and 6 CCR 1007-3, Part 264, Subpart F, for the post-closure care period for regulated units. Presented in Section E are results of interim status monitoring at that time and plans for continued interim status monitoring. Also presented are descriptions of the uppermost aquifer and contaminant plumes based on data available at that time.

1.1 GROUND-WATER MONITORING AT ROCKY FLATS PLANT

Ground-water monitoring for radionuclides and other parameters has been conducted at Rocky Flats Plant since the first monitoring wells were installed in 1960. A total of 56 wells were installed at the Plant between 1960 and 1985. These wells were routinely sampled for radionuclides, and beginning in 1985, they were sampled for other chemical parameters (volatile organics, trace metals, and major ions). There are no well completion details for wells installed prior to 1986.

In late 1986, Phase I of a comprehensive program of site characterizations, remedial investigations, feasibility studies, and remedial/corrective actions began at the Rocky Flats Plant. These investigations were pursuant to the U.S. Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) and a Compliance Agreement finalized by representatives of the DOE, the EPA, and the CDH on 31 July 1986. CEARP is now known as the Environmental Restoration (ER) Program.

Sixty-nine (69) monitoring wells were installed in 1986 to characterize the hydrogeology and ground-water quality of the entire Plant and to satisfy RCRA Subpart F requirements. The work plan for installation, sampling, and analysis of these wells is presented in the Geological and Hydrological Site Characterization Draft Work Plan for Rocky Flats Plant (Rockwell International, 1986a). Site characterization and plume delineation wells were installed at the Solar Evaporation Ponds (assessment monitoring program), and site characterization wells were constructed at the West Spray Field and Present Landfill (alternate monitoring programs) as part of the Plant-wide characterization program.

Phase I investigations included:

1) detailed characterization of ground-water flow and quality in the vicinity of the solar evaporation ponds;

2) preparation of the ground-water monitoring and protection section of the Rocky Flats Plant RCRA Part B permit application (Rockwell International, 1986b);

3) preparation of closure plans for the West Spray Field, Present Landfill, and Solar Evaporation Ponds; and

4) preparation of a RCRA Post-Closure Care Permit Application for regulated units undergoing closure.

An additional 67 wells were installed at Rocky Flats Plant in 1987 to characterize ground-water quality and flow at various Solid Waste Management Units (SWMUs) and at the RCRA regulated units. The designation, Solid Waste Management Unit, is equivalent to the term CERCLA site. This equivalency applies to all SWMUs other than the regulated units. The work plans for installation, sampling, and analysis of these wells are presented in the CEARP Installation Generic and Site Specific (Remedial Investigation) Work Plans (U.S. DOE, 1987a and U.S. DOE, 1987b).

Ground water at the Rocky Flats Plant has been analyzed for the EPA Contract Laboratory Program (CLP) Hazardous Substance List (HSL), Target Compound List (TCL) and Target Analyte List (TAL) as well as other inorganic and radiochemical parameters. The TCL and TAL superceded the HSL in late 1988. A comparison of these lists to the RCRA Appendix IX Ground-Water Monitoring List (40 CFR Part 264, Appendix IX) is shown in Table 1-1. (Ground-water samples will be analyzed annually for the Appendix IX list for regulated units in compliance monitoring (Solar Evaporation Ponds) once a Post Closure Care Permit is issued). During 1986 ground-water samples were analyzed for HSL volatiles, semi-volatiles, and metals as well as major ions and radionuclides. In 1987 and 1988 analyses were performed by an on-site Rockwell International laboratory. During the first three quarters of 1987, the volatile organic analyte list was reduced to the nine volatile compounds previously detected in ground water at the Plant; tetrachloroethene (PCE), trichloroethene (TCE), 1,1-Dichloroethene (1,1-DCE), 1,2-Dichloroethane (1,2-DCA), trans-1,2-Dichloroethene (t-1,2-DCE), 1,1,1-Trichloroethane (1,1,1-TCA), 1,1,2-Trichloroethane (1,1,2-TCA), carbon tetrachloride (CCl_4), and chloroform ($CHCl_3$). During the fourth quarter of 1987, the Rockwell laboratory obtained a gas chromatograph/mass spectrometer and began analyzing for HSL volatile organic compounds. The current ground-water monitoring analytical suite, that was also in effect in 1989, is shown in Table 1-2. Other changes in the historical analytical program are identified in the table.

Quarterly sampling of monitoring wells at Rocky Flats Plant is initiated immediately upon their completion and development. In general, the 1986 and 1987 wells were sampled once during the year they were installed and quarterly in subsequent years. The 1989 wells were sampled once in 1989 and have been added to the quarterly monitoring program for 1990. Water levels were generally measured monthly as well as at the time of sampling; however, during the fourth quarter, 1989 water levels were taken once in September and once at the time of sampling. The unconfined water table in surficial materials at Rocky Flats Plant is

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TABLE 1-1

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL),
TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

VOLATILES	HSL	TCL	Appendix IX
Chloromethane/Methyl chloride	X	X	X
Bromomethane/Methyl bromide	X	X	X
Vinyl chloride	X	X	X
Chloroethane/Ethyl chloride	X	X	X
Methylene chloride/Dichloromethane	X	X	X
Acetone	X	X	X
Carbon disulfide	X	X	X
1,1-Dichloroethene/1,1-Dichloroethylene	X	X	X
1,1-Dichloroethane/Ethylidene Dichloride	X	X	X
1,2-Dichloroethene (total)	X	X	X
Chloroform	X	X	X
1,2-Dichloroethane/Ethylene Dichloride	X	X	X
2-Butanone/Methyl ethyl ketone/MEK	X	X	X
1,1,1-Trichloroethane/Methyl chloroform	X	X	X
Carbon tetrachloride	X	X	X
Vinyl acetate	X	X	X
Bromodichloromethane	X	X	X
1,2-Dichloropropane	X	X	X
cis-1,3-Dichloropropene	X	X	X
Trichloroethene	X	X	X
Dibromochloromethane/Chlorodibromomethane	X	X	X
1,1,2-Trichloroethane	X	X	X
Benzene	X	X	X
trans-1,3-Dichloropropene	X	X	X
2-Chloroethyl Vinyl Ether	X		
Bromoform/Tribromomethane	X	X	X
4-Methyl-2-pentanone/MIBK	X	X	X
2-Hexanone	X	X	X
Tetrachloroethene/PCE/Tetrachloroethylene	X	X	X
1,1,2,2-Tetrachloroethane	X	X	X
Toluene	X	X	X
Chlorobenzene	X	X	X
Ethylbenzene	X	X	X
Styrene	X	X	X
Xylene (total)	X	X	X
Dichlorodifluoromethane			X
Acetonitrile/Methyl cyanide			X
Iodomethane/Methyl iodide			X
Acrolein			X
Acrylonitrile			X
Trichlorofluoromethane			X
Propionitrile/Ethyl cyanide			X
3-Chloropropene/Allyl chloride			X
Methacrylonitrile			X
Dibromomethane/Methylene bromide			X
Isobutyl alcohol/Isobutanol			X
1,2-Dibromoethane/Ethylene dibromide/EDB			X
1,1,1,2-Tetrachloroethane			X
1,2,3-Trichloropropane			X
trans-1,4-Dichloro-2-butene			X
1,2-Dibromo-3-chloropropane/DBCP			X
Chloroprene/2-Chloro-1,3-butadiene			X

TABLE 1-1
(Continued)

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL), TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

SEMI-VOLATILES	HSL	TCL	Appendix IX
Phenol	X	X	X
bis-(2-Chloroethyl) ether	X	X	X
2-Chlorophenol/o-Chlorophenol	X	X	X
1,3-Dichlorobenzene/m-Dichlorobenzene	X	X	X
1,4-Dichlorobenzene/p-Dichlorobenzene	X	X	X
Benzyl alcohol	X	X	X
1,2-Dichlorobenzene/o-Dichlorobenzene	X	X	X
2-Methylphenol/o-Cresol	X	X	X
bis (2-Chloroisopropyl) ether	X	X	X
4-Methylphenol/p-Cresol	X	X	X
N-Nitroso-di-n-propylamine	X	X	X
Hexachloroethane	X	X	X
Nitrobenzene	X	X	X
Isophorone	X	X	X
2-Nitrophenol/o-Nitrophenol	X	X	X
2,4-Dimethylphenol	X	X	X
Benzoic Acid	X	X	
bis(2-Chloroethoxy)methane	X	X	X
2,4-Dichlorophenol	X	X	X
1,2,4-Trichlorobenzene	X	X	X
Naphthalene	X	X	X
4-Chloroaniline/p-Chloroaniline	X	X	X
Hexachlorobutadiene	X	X	X
4-Chloro-3-methylphenol/p-Chloro-m-cresol	X	X	X
2-Methylnaphthalene	X	X	X
Hexachlorocyclopentadiene	X	X	X
2,4,6-Trichlorophenol	X	X	X
2,4,5-Trichlorophenol	X	X	X
2-Chloronaphthalene	X	X	X
2-Nitroaniline/o-Nitroaniline	X	X	X
Dimethylphthalate	X	X	X
Acenaphthylene	X	X	X
2,6-Dinitrotoluene	X	X	X
3-Nitroaniline/m-Nitroaniline	X	X	X
Acenaphthene	X	X	X
2,4-Dinitrophenol	X	X	X
4-Nitrophenol/p-Nitroaniline	X	X	X
Acenaphthene	X	X	X
2,4-Dinitrophenol	X	X	X
4-Nitrophenol/p-Nitrophenol	X	X	X
Dibenzofuran	X	X	X
2,4-Dinitrotoluene	X	X	X
Diethylphthalate	X	X	X
4-Chlorophenyl-phenylether	X	X	X
Fluorene	X	X	X
4-Nitroaniline/p-Nitroaniline	X	X	X
4,6-Dinitro-2-methylphenol	X	X	X
N-Nitrosodiphenylamine	X	X	X
4-Bromophenyl-phenylether	X	X	X
Hexachlorobenzene	X	X	X
Pentachlorophenol	X	X	X

TABLE 1-1
(Continued)

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL), TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

SEMI-VOLATILES (continued)	HSL	TCL	Appendix IX
Phenanthrene	X	X	X
Anthracene	X	X	X
Di-n-butylphthalate	X	X	X
Fluoranthene	X	X	X
Benzidiene	X		
Pyrene	X	X	X
Butylbenzylphthalate	X	X	X
3,3'-Dichlorobenzidine	X	X	X
Benzo [a] anthracene/1,2-Benzanthracene	X	X	X
Chrysene	X	X	X
bis (2-Ethylhexyl) phthalate	X	X	X
Di-n-octylphthalate	X	X	X
Benzo [b] fluoranthene	X	X	X
Benzo [k] fluoranthene	X	X	X
Benzo [a] pyrene	X	X	X
Ideno [1,2,3-cd] pyrene	X	X	X
Dibenz [a,h] anthracene	X	X	X
Benzo [ghi] perylene	X	X	X
1,4-Dioxane/p-Dioxane			X
Methyl methacrylate			X
Pyridine			X
N-Nitrosodimethylamine	X		X
Ethyl methacrylate			X
2-Picoline/2-Methylpyridine			X
N-Nitrosomethylethylamine			X
Methyl methanesulfonate			X
N-Nitrosodiethylamine			X
Ethyl methanesulfonate			X
Aniline	X		X
Pentachloroethane			X
3-Methylphenol/m-Cresol			X
N-Nitrosopyrrolidine			X
Acetophenone			X
N-Nitrosomorpholine			X
o-Toluidine			X
N-Nitrosopiperidine			X
alpha, alpha-dimethylphenethylamine			X
2,6-Dichlorophenol			X
Hexachloropropene			X
p-Phenylenediamine			X
N-Nitroso-di-n-butylamine			X
Safrole			X
1,2,4,5-Tetrachlorobenzene			X
Isosafrole			X
1,4-Naphthoquinone			X
1,3-Dinitrobenzene/m-Dinitrobenzene			X
Pentachlorobenzene			X
1-Naphthylamine			X
2-Naphthylamine			X
2,3,4,6-Tetrachlorophenol			X
1,3,5-Trinitrobenzene/sym-Trinitrobenzene			X
Diallate			X

TABLE 1-1
(Continued)

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL), TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

SEMI-VOLATILES (Continued)	HSL	TCL	Appendix IX
Phenacetin			X
Diphenylamine			X
5-Nitro-o-toluidine			X
4-Aminobiphenyl			X
Pronamide			X
2-sec-Butyl-4,6-dinitrophenol/Dinoseb			X
Pentachloronitrobenzene			X
4-Nitroquinoline-1-oxide			X
Methapyrilene			X
Aramite			X
Chlorobenzilate			X
p-Dimethylaminoazobenzene			X
3-3'-Dimethylbenzidine			X
2-Acetylaminofluorene/2-AAF			X
7,12-Dimethylbenz [a] anthracene			X
Hexachlorophene			X
3-Methylcholanthrene			X
PESTICIDE/PCBs			
alpha-BHC	X	X	X
beta-BHC	X	X	X
delta-BHC	X	X	X
gamma-BHC/Lindane	X	X	X
Heptachlor	X	X	X
Aldrin	X	X	X
Heptachlor epoxide	X	X	X
Endosulfan I	X	X	X
Dieldrin	X	X	X
4,4'-DDE	X	X	X
Endrin	X	X	X
Endosulfan II	X	X	X
4,4'-DDD	X	X	X
Endosulfan sulfate	X	X	X
4,4'-DDT	X	X	X
Methoxychlor	X	X	X
Endrin ketone	X	X	
alpha-Chlordane (shown as total on Appendix IX and HSL)	X	X	X
gamma-Chlordane (shown as total on Appendix IX and HSL)	X	X	X
Toxaphene/Camphechlor	X	X	X
Aroclor-1016 (shown as total on Appendix IX)	X	X	X
Aroclor-1221 (shown as total on Appendix IX)	X	X	X
Aroclor-1232 (shown as total on Appendix IX)	X	X	X
Aroclor-1242 (shown as total on Appendix IX)	X	X	X
Aroclor-1248 (shown as total on Appendix IX)	X	X	X
Aroclor-1254 (shown as total on Appendix IX)	X	X	X
Aroclor-1260 (shown as total on Appendix IX)	X	X	X
Isodrin (Stereoisomer of Aldrin)			X
Kepone			X
Endrin aldehyde	X		X

TABLE 1-1
(Continued)

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL), TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

ORGANO PHOSPHORUS PESTICIDES	HSL	TCL	Appendix IX
Thionazin			X
Phorate			X
Disulfoton/Di-Syston			X
Dimethoate			X
Methyl Parathion			X
Parathion			X
Famphur/Famophos			X
O,O,O-Triethyl phosphorothioate			X
Sulfotepp/Tetraethyl dithiopyrophosphate			X
HERBICIDES			
2,4-D/2,4-Dichlorophenoxyacetic acid			X
2,4,5-TP/Silvex			X
2,4,5-T/2,4,5-Trichloroacetic acid			X
DIOXINS			
Polychlorinated di-benzo-p-dioxins/PCDDs			X
Polychlorinated di-benzofurans/PCDFs			X
2,3,7,8-Tetrachlorodibenzo-p-dioxin			X

INORGANIC ANALYTES*	HSL	TAL**	Appendix IX
Aluminum	X	X	
Antimony	X	X	X
Arsenic	X	X	X
Barium	X	X	X
Beryllium	X	X	X
Cadmium	X	X	X
Calcium	X	X	
Chromium	X	X	X
Cobalt	X	X	X
Copper	X	X	X
Iron	X	X	
Lead	X	X	X
Magnesium	X	X	
Manganese	X	X	
Mercury	X	X	X
Nickel	X	X	X
Potassium	X	X	
Selenium	X	X	X
Silver	X	X	X
Sodium	X	X	X
Thallium	X	X	X
Tin	X		X
Vanadium	X	X	X

TABLE 1-1
(Continued)

COMPARISON OF HAZARDOUS SUBSTANCE LIST (HSL),
TARGET COMPOUND LIST (TCL), AND RCRA APPENDIX IX CONSTITUENTS

INORGANIC ANALYTES* (continued)	HSL	TAL**	Appendix IX
Zinc	X	X	X
Cyanide		X	X
Sulfide			X

* Current analytical program includes cesium, chromium (VI), lithium, molybdenum, and strontium which are non-Appendix IX and non-TAL constituents. It also includes analysis for tin, a non-TAL constituent.

** TAL - Target Analyte List

TABLE 1-2

GROUND-WATER SAMPLING PARAMETERS
DURING 1989

FIELD PARAMETERS
pH
Specific Conductance
Temperature

INDICATORS
Total Dissolved Solids
pH (1)

METALS
Target Analyte List
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc

Cesium
Lithium (2)
Molybdenum
Strontium
Tin (1)

ANIONS
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide (as N) (3)

ORGANICS (7)
Target Compound List - Volatiles:
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride

TABLE 1-2
(continued)
GROUND-WATER SAMPLING PARAMETERS
DURING 1989

ORGANICS (7) (continued)

- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Ethyl Benzene
- Styrene
- Total Xylenes

RADIONUCLIDES (4)

- Gross Alpha
- Gross Beta
- Uranium 233+234, 235, and 238
- Americium 241
- Plutonium 239+240
- Strontium 89+90 (5)
- Cesium 137
- Tritium
- Radium 226,228 (6)

(1) Not analyzed prior to 1989.
(2) Prior to 1989, lithium was only analyzed during fourth quarter 1987 and first quarter 1988.
(3) Cyanide was not analyzed during fourth quarter 1987.
(4) Dissolved radionuclides replaced total radionuclides (except tritium) beginning with the third quarter 1987.
(5) Strontium 89+90 was not analyzed during first quarter 1988.
(6) Not analyzed prior to 1989, and only analyzed if gross alpha exceeds 5 pCi/l.
(7) Not analyzed in background samples in 1989.

NOTES:

- Total suspended solids and phosphate were analyzed in 1986 only.
- Chromium (VI) was analyzed during fourth quarter 1987 only.

dynamic; thus, some wells are dry upon inspection for quarterly sampling, and no sample is collected. At other times there is insufficient water in wells to analyze for the entire parameter list. When this situation occurs, sample collection is prioritized as follows:

- Volatile Organic Compounds;
- Plutonium, Uranium, and Americium;
- Nitrate;
- Metals;
- Other Major Ions; and
- Other Radionuclides.

During the fourth quarter 1989 sampling effort, the priority list for low production wells was modified as follows:

- Volatile Organic Compounds;
- Plutonium and Uranium;
- Major Ions;
- Nitrate;
- Gross Alpha and Gross Beta;
- Metals;
- Strontium;
- Cesium;
- Tritium;
- Americium; and
- Cyanide.

Sampling and analysis records are maintained quarterly in compliance with 6 CCR 1007-3 and 40 CFR 265.94(b). Annual reports were compiled in March 1988 and March 1989, which describe ground-water elevations, ground-water migration rates, and include the results of the ground-water sample analyses for the respective years (Rockwell International, 1988 and 1989a).

1.2 PURPOSE AND SCOPE

This report presents interim status 1989 quarterly ground-water monitoring results for the Solar Evaporation Ponds, Present Landfill, and West Spray Field in accordance with 6 CCR 1007-3, Part 265.94 (Plate 1-1). Included are available analytical ground-water quality data for the first through fourth quarters of 1988 and 1989 (Appendices A through F) and an evaluation of these data in accordance with 6 CCR 1007-3, Part 264.94(b). All 1988 data have been received at this time. With the exception of radiochemistry data, all first and second quarter 1989 data have also been received. Limited data are available for third and fourth quarter 1989 and are summarized in Table 1-3. The only data that have been validated in accordance with the ER Program Quality Assurance/Quality Control Program are fourth quarter 1988 and first and second quarter 1989 volatile organics data. In the appendices, a qualifier has been added to each datum (V - valid; A - acceptable; R - rejected) identifying the results of the validation process for these data. As not all data are available for report submission or have been validated, an addendum will be submitted at a later date providing all the 1989 data and revised interpretation of the data if so warranted.

Plans for an Original Process Waste Line interim status alternate monitoring system are presented in Section E of the Post-Closure Care Permit Application (U.S. DOE, 1988). Although these investigations have begun, there are insufficient data at this time for a report submittal. Therefore, the Original Process Waste Line regulated unit is not addressed in this report.

1.3 GROUND-WATER QUALITY ASSESSMENT APPROACH

1.3.1 Interpretation of Uppermost Aquifer

Aquifer and uppermost aquifer are specifically defined in the RCRA regulations. An aquifer "means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of ground water to wells or springs". The uppermost aquifer "means the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this

TABLE 1-3
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Solar Evaporation Ponds)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0260			M				M	M				M			M		M	M	M	M			M	M	M	M	M	M
0460			M	M			M	M				M			M		M	M	M	M			M	M	M	M	M	M
1386			M				M	M			M	M			M				M	M			M	M			M	M
1486			M	M			M	M				M			M		M			M		M	M	M	M	M	M	M
1586			M				M	M				M			M		M		M	M			M	M	M	M	M	M
1686			M				M	M				M			M		M		M	M			M	M	M	M	M	M
1786			M	M			M	M				M			M	M	M		M	M			M	M	M	M	M	M
1886			M				M				M				M				M				M				M	
2086			M				M				M				M				M				M				M	
2187																				M				M				M
2286			M				M				M				M				M	M			M	M			M	M
2287BR			M				M								M		M			M			M	M			M	M
2386			M				M				M				M				M	M			M	M			M	M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Solar Evaporation Ponds)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
2486			M				M				M				M				M				M				M	
2586			M	M			M	M				M			M		M		M	M			M	M	M	M	M	M
2686			M				M				M				M				M				M				M	
2786			M	M			M	M				M			M					M			M	M			M	M
2886			M	M			M	M				M			M					M			M	M			M	M
2986			M				M				M				M				M				M				M	
3086			M				M								M		M		M	M			M	M	M	M	M	M
3186			M				M				M				M				M				M				M	
3286			M	M			M	M				M			M				M	M			M	M	M	M	M	M
3386																												
3486			M	M			M	M				M				M	M			M				M	M	M	M	M
3586				M				M				M					M			M				M	M	M		M
3686				M																								

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Solar Evaporation Ponds)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
3787			M	M			M	M			M	M			M				M	M			M	M			M	M
3887			M	M			M	M			M	M			M				M	M			M	M			M	M
3987BR			M	M			M				M				M				M	M			M	M			M	M
5687			M	M			M	M			M	M			M				M	M			M	M			M	M
P207389																												
P207489								M				M																
P207589				M				M				M				M				M				M				M
P207689																												
P207789																												
P207889																				M								M
P207989								M				M								M								M
B208089																												
B208189																				M								M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Solar Evaporation Ponds)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
B208289																												
B208389																												
B208489																												
B208589																												
B208689																M												
B208789																												
P208889								M				M								M				M				M
P208989				M				M				M								M				M				M
P209089				M				M				M				M				M				M				M
P209189				M				M				M																
P209289																												
P209389																				M				M				M
P209489				M				M				M																

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Solar Evaporation Ponds)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
P209589								M				M								M				M				M
P209689								M				M				M				M				M				M
P209789																												
P209889				M				M				M								M				M				M
P209989																												
P210089								M				M				M				M								M
P210189				M				M				M																
P210289				M																M								M
B210389																				M				M				M
B210489																				M				M				M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(West Spray Field)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0582			M	M			M	M				M			M		M	M	M	M			M	M	M	M	M	M
0682			M	M			M	M			M	M			M		M	M	M	M			M	M	M	M	M	M
0782				M																M				M				M
0881			M				M								M		M	M	M				M		M	M	M	
0981			M	M			M	M				M			M		M	M	M	M			M	M	M	M	M	M
1081				M			M	M			M	M			M		M	M		M			M	M	M	M	M	M
4586			M	M			M	M				M			M		M	M	M	M			M	M	M	M	M	M
4686				M			M	M			M	M			M		M	M	M	M			M	M	M	M	M	M
4786				M			M	M			M	M			M		M			M			M	M	M	M	M	M
4886			M				M	M				M			M		M	M		M			M	M	M	M	M	M
4986			M	M			M	M				M			M		M	M		M			M	M	M	M	M	M
5086			M				M	M				M			M		M	M	M	M			M	M	M	M	M	M
5186							M				M				M		M	M	M	M			M	M	M	M	M	M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(West Spray Field)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
5286							M				M				M		M			M			M	M	M	M	M	M
5686				M			M	M			M	M			M		M	M		M			M	M	M	M	M	M
B410589																												
B410689				M				M																				
B410789				M				M				M								M				M				M
B110889				M				M				M								M				M				M
B110989																												
B111189				M				M				M								M				M				M
B411289				M				M				M								M				M				M
B411389				M				M				M								M				M				M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Present Landfill)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0586			M	M			M				M				M				M				M				M	
0686			M				M				M				M				M				M				M	
0786			M	M			M				M				M				M				M				M	
0886			M	M			M				M				M				M	M			M	M			M	M
0986			M	M			M	M				M			M		M	M		M			M	M	M	M	M	M
1086			M	M			M	M				M			M		M	M		M			M	M	M	M	M	M
4087			M				M				M				M				M				M				M	
4187BR			M	M			M	M			M	M			M			M	M	M			M	M			M	M
4287			M				M				M				M		M	M	M				M		M	M	M	
5887			M	M			M	M			M	M			M	M	M	M	M	M			M	M	M	M	M	M
6087			M				M								M		M			M			M	M	M	M	M	M
6187			M	M			M	M				M			M		M		M	M			M	M	M	M	M	M
6287			M	M			M	M				M			M		M		M	M			M	M	M	M	M	M

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Present Landfill)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
6387			M	M			M	M				M			M			M	M	M		M	M	M	M	M	M	M
6487			M	M			M	M			M	M			M				M	M			M	M			M	M
6587			M				M				M				M		M		M	M			M	M	M	M	M	M
6687			M	M				M				M			M		M	M		M			M	M	M	M	M	M
6787			M	M			M	M				M			M		M		M	M			M	M	M	M	M	M
6887			M	M			M	M				M			M		M		M	M			M	M	M	M	M	M
7087			M	M			M								M		M		M	M			M	M	M	M	M	M
7187																	M			M			M	M	M	M	M	M
7287			M	M			M				M				M				M				M				M	
B106089				M				M				M								M				M				M
B206189				M																M								M
B206289				M				M				M								M								M
B206389																												

TABLE 1-3 (CONTINUED)
STATUS REPORT OF 1989 GROUND-WATER SAMPLING RESULTS
(Present Landfill)
(M = MISSING)

WELL NUMBER	VOLATILE				ICP METALS				AA METALS				INORGANICS				ALPHA, BETA				TRITIUM				OTHER RADS			
QTR->	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
B206489				M																M				M				M
B206589				M				M				M								M								M
B206689								M				M								M								M
B206789				M																M								M
B206889								M				M				M				M				M				M
B206989								M				M								M				M				M
B207089				M				M				M																
B207189																								M				
B207289																												

aquifer within the facility's property boundary". Because there are many water bearing units at the Rocky Flats Plant, it is necessary that these definitions be interpreted for development of practical ground-water monitoring systems which are in keeping with the intent of the Subpart F ground-water protection regulations.

The water bearing units at the Rocky Flats Plant consist of alluvium, colluvium, valley fill alluvium, and sandstone and claystones of the Arapahoe Formation. The alluvium, colluvium, and valley fill alluvium fit the RCRA definition of the uppermost aquifer based on their proximity to the ground surface and high hydraulic conductivities relative to the other units. Conversely, the unweathered claystone is not an aquifer because of its low hydraulic conductivity (generally on the order of 1×10^{-7} to 1×10^{-8} centimeters per second [cm/sec]). This leaves for interpretation if weathered claystone and sandstones, which are hydraulically interconnected with the alluvial systems, are a part of the uppermost aquifer. In some locations weathered claystones and sandstones exhibit hydraulic conductivities similar to the unweathered claystone and therefore should not be considered a part of the uppermost aquifer. However, because hydraulic conductivities for these units vary across the Plant site, and in some instances these units crop out beneath the regulated units, weathered claystones and sandstones will be considered part of the uppermost aquifer when:

1) they crop out beneath the regulated unit, or

2) they subcrop in saturated surficial materials that have been contaminated by the regulated unit, regardless of location with respect to the regulated unit.

The above interpretation of the uppermost aquifer provides the basis for the ground-water monitoring systems described in this report for detecting releases at the point of compliance and plume characterization. It does not imply that these hydrogeologic units are aquifers capable of providing a significant source of useable ground water. A "significant source of ground water" as used in 40 CFR Part 191 (Environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes) means:

(1) an aquifer that:

- (i) is saturated with water having less than 10,000 milligrams per liter of total dissolved solids;
- (ii) is within 2,500 feet of the land surface;
- (iii) has a transmissivity greater than 200 gallons per day per foot, provided that any formation or part of a formation included within the source of ground-water has a hydraulic conductivity greater than 2 gallons per day per square foot (5.3×10^{-3} cm/sec); and

(iv) is capable of continuously yielding at least 10,000 gallons per day (6.9 gallons per minute) to a pumped or flowing well for a period of at least a year; or

(2) An aquifer that provides the primary source of water for a community water system as part of the effect data of this subpart.

In general, due to the partially saturated conditions within surficial materials and the low hydraulic conductivities of bedrock materials at the Plant, it is unlikely that either of these units will ever be developed for ground-water use.

1.3.2 Ground-water Quality Assessment

For assessment and alternate ground-water monitoring programs, the operator is required, at the minimum, to determine:

1) whether hazardous waste or hazardous waste constituents have entered the ground water;

2) the rate and extent of migration of the hazardous waste or hazardous waste constituents in the ground water; and

3) the concentrations of the hazardous waste or hazardous waste constituents in the ground water (6 CCR 1007-3 265.93 (a), 40 CFR 265.93(d)(4)).

In order to facilitate the interpretation of ground-water contamination at the regulated units, a background characterization program has been implemented to define the spatial and temporal variability of naturally occurring constituents. Field work was conducted in 1989 and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies December 15, 1989 (Rockwell International, 1989b). The document summarizes the background data for ground water, surface water, sediments, and geologic materials, and identifies preliminary statistical boundaries of background variability. Spatial variations in the chemistry of geologic materials and water were addressed by placing sample locations throughout background areas at the Plant. The goal of evaluating temporal variations in water chemistry has not yet been achieved because at least two years of quarterly data are needed. The draft report will be updated in 1990 by incorporation of analytical data that were unavailable in December 1989, including a second round of ground-water samples for which laboratory analyses were not available. The information in the draft background geochemical report (one round of ground water samples) has been used to preliminarily characterize inorganic contamination at the regulated units.

The boundary of background variability was quantified through the calculation of tolerance intervals assuming a normal distribution. The upper limit of the tolerance interval or the maximum detected value for each parameter analyzed in background ground-water, are provided in Table 1-4. Maximum detected values are provided where there were insufficient data to calculate tolerance intervals. This condition resulted from there being an insufficient number of samples, or where there was an insufficient number of detectable concentrations for a given analyte. Background samples were not analyzed for EPA CLP TCL organics, because they are not expected to be present.

To assess the presence of inorganic contamination at the regulated units, site-specific chemical data from second quarter 1989 (or second quarter 1988 if 1989 data are unavailable) are compared to the background tolerance intervals or the maximum detected value if a tolerance interval could not be calculated. Second quarter data are chosen because they correspond with the same season as the background data and the greatest extent of saturated surficial materials occurs during second quarter. A constituent concentration that is greater than the upper limit of the one-sided 95% tolerance interval at the 95% confidence level will be considered to preliminarily represent contamination. However, there is no statistical significance associated with site specific chemical concentrations being above the maximum detected background value. For organic analytes, concentrations at or above the detection limits defined in the ER Program Quality Assurance/Quality Control Plan (Rockwell International, 1989c) are considered potential contamination. All 1988 and 1989 data will be reviewed to assure that conclusions drawn based on second quarter data are supported by data from other quarters. For graphical presentation, fourth quarter 1989 data have been used to construct isopleth maps, because the data are most complete for this quarter considering that it includes the only data for the newly installed 1989 wells.

Many of the ground-water parameters that are analyzed are RCRA hazardous constituents as defined in the 40 CFR Part 261 Appendix VIII. With the exception of the Safe Drinking Water Act (SDWA) metals, all hazardous constituents must be at background concentrations at the compliance point unless alternate concentration limits are proposed. SDWA metals may be present above background but not above National Primary Drinking Water Standards [40 CFR 264.94(a)(2)]. These background concentrations and drinking water standards are known as proposed concentration limits and are shown in Table 1-5.

TABLE 1-4

BACKGROUND GROUND-WATER (ROUND 1)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Dissolved Metals							
Aluminum	mg/l	ND	ND	ND	ND	ND	0.327*
Antimony	mg/l	ND	ND	ND	ND	ND	ND
Arsenic	mg/l	ND	ND	ND	ND	ND	0.0186*
Barium	mg/l	ND	ND	ND	ND	ND	ND
Beryllium	mg/l	ND	ND	ND	ND	ND	ND
Cadmium	mg/l	ND	ND	ND	ND	ND	ND
Calcium	mg/l	85	76.8*	138	73.4*	65.7*	64.6
Cesium	mg/l	ND	ND	ND	ND	ND	ND
Chromium	mg/l	ND	ND	ND	ND	0.0122*	ND
Cobalt	mg/l	ND	ND	ND	ND	ND	ND
Copper	mg/l	ND	ND	ND	ND	ND	ND
Iron	mg/l	0.266*	ND	0.94*	ND	ND	ND
Lead	mg/l	ND	ND	ND	ND	ND	ND
Lithium	mg/l	ND	0.172*	0.028	.031*	0.0106*	ND
Magnesium	mg/l	5.79*	15.3*	26.57	45.3*	9.41*	ND
Manganese	mg/l	0.365	0.088*	0.686*	0.126*	0.292*	0.0182*
Mercury	mg/l	ND	ND	0.003*	.008*	ND	ND
Molybdenum	mg/l	0.0136*	ND	ND	0.015*	0.015*	0.112*
Nickel	mg/l	0.0432*	ND	ND	ND	ND	ND
Potassium	mg/l	7.73*	ND	ND	ND	ND	21.89*
Selenium	mg/l	ND	ND	0.0114*	ND	ND	0.041*
Silver	mg/l	ND	ND	ND	ND	ND	ND
Sodium	mg/l	13.4	98.7*	88	36.9*	25.6*	599
Strontium	mg/l	0.159*	ND	ND	ND	ND	0.451*
Thallium	mg/l	ND	ND	ND	0.01*	ND	ND
Tin	mg/l	ND	ND	ND	ND	ND	
Vanadium	mg/l	ND	ND	ND	ND	ND	ND
Zinc	mg/l	0.141*	ND	0.0212*	0.107*	ND	0.564

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TABLE 1-4 (cont.)

BACKGROUND GROUND-WATER (ROUND 1)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Other							
Total Dissolved Solids	mg/l	352	520*	947	320*	170*	1761
Carbonate	mg/l	ND	ND	ND	ND	ND	49
Bicarbonate	mg/l	436	470*	719	400*	140*	412
Chloride	mg/l	15.6	20*	40.29	11*	15*	607
Sulfate	mg/l	45.1	86*	150	44*	16*	950
Nitrate	mg/l	2.98	0.18*	0.69*	0.58*	1.6*	0.610
Cyanide	mg/l	.0038*	ND	ND	0.0036*	ND	ND
pH	----	8.6 (5.98)	7.4* (7.1)**	8.68 (6.12)	8.2* (7.4)**	7.5* (7.2)**	10.57 (7.43)***
Dissolved Radionuclides							
Gross Alpha	pCi/l	12.543	27*	13.515	12*	7*	13*
Gross Beta	pCi/l	14.570	12*	18.530	7*	2*	15*
Uranium 233, 234	pCi/l	1.647	11*	6.481	5.8*	1.1*	12.936
Uranium 235	pCi/l	0.000	0.3*	0.232	0.2*	0*	0.135
Uranium 238	pCi/l	0.195	7.7*	5.084	3.2	0.6*	3.3507
Strontium 89, 90	pCi/l	0.552	0.1*	0.878	0.1	-0.1*	0.2*
Plutonium 239, 240	pCi/l	0.009	0*	0.012	0.03	0.01*	0.000
Americium 241	pCi/l	0.000	0*	0.012	0	0.01*	0.019
Cesium 137	pCi/l	0.603	0.2*	0.776	0.4	0.3*	0.7*
Tritium	pCi/l	309	100*	505	100	100*	731

* - Maximum Detected Value
** - Minimum Detected Value
*** - It is conjectured that bentonite may have been introduced into the screened section of the well during placement of the bentonite bottom seal. A bentonite/water slurry has a pH between 10 and 11.
ND - Not Detected at Contract Required Detection Limit
() - Tolerance Internal Lower Limit for Two-Sided Parameter

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TABLE 1-5

PROPOSED CONCENTRATION LIMITS

Constituent	Concentration
Dissolved Metals (mg/l)	
++Ag	BKG*
Al	5.0
++As	0.05**
++Ba	1.0**
+Be	BKG
Ca	NS
++Cd	0.01**
+Co	BKG
++Cr	0.05**
Cs	BKG***
+Cu	BKG
Fe	0.3**+
++Hg	0.002**
K	NS
+Li	BKG
Mg	NS
Mn	BKG*++
Mo	0.1++*
Na	NS
+Ni	BKG
++Pb	0.05**
+Sb	BKG
++Se	0.01**
Sr	BKG***
+Tl	BKG
+V	BKG
+Zn	BKG
Other Inorganics (mg/l):	
HCO_3	NS
Cl	250**+
SO_4	250**+
NO_3	10**+
TDS	400++*
Dissolved Radionuclides (pCi/l):	
Gross Alpha	11**+
Gross Beta	19**+
Pu 239, 240	0.05**+
Am 241	0.05**+
Total Uranium	5**+
Sr 89,90	8++*
Cs 137	NS
H3	500**+

TABLE 1-5
(continued)

PROPOSED CONCENTRATION LIMITS

*	See Table 1-3 for upper limit of background range.
**	Primary Drinking Water Standard.
***	Although not Appendix VIII constituents, health based standards do not exist and therefore the proposed concentration limit for cesium and strontium is background.
•**	Unweathered sandstone ground water has a background concentration (upper limit of range) less than 0.05 mg/l, the CDH ground water standard. Therefore, for this ground water the CDH standard is the proposed concentration limit.
***	Colorado Surface Water Standard.
***	Colorado Ground Water Standard.
+	Appendix VIII constituent.
+ +	Appendix VIII constituent and SDWA metal.
BKG	Background
NS	No standard.

Concentration limits may also be established for non-Appendix VIII constituents where necessary to protect human health and the environment. These are the Federal Register, Table 1 constituents (52 FR 25944). Concentration limits are proposed for these and other non-hazardous organic and inorganic constituents, and radionuclides. Since Great Western Reservoir is located downgradient of the regulated units, CDH surface water standards for Walnut Creek are considered primary when setting concentration limits for non-hazardous constituents. If a surface water standard has not been promulgated, proposed concentration limits are set by the CDH ground-water standards for the protection of human health, or for the protection of agriculture if human health standards have not been established.

Although "proposed concentration limits" is a term applicable only to permitted facilities, the significance, in terms of protection of human health and the environment, of constituents above background levels is discussed in this report based on these limits.

4.0 GROUND-WATER MONITORING AT THE PRESENT LANDFILL

The Present Landfill is located on the western end of an unnamed tributary to North Walnut Creek (Plate 1-1). The landfill was placed in operation on August 14, 1968, after a study determined that a landfill operation would be the most efficient and economical means to dispose of the Plant's solid waste. A number of available sites within the Plant boundaries were evaluated, and the site at the west end of the North Walnut Creek unnamed tributary was selected. The drainage was filled with five feet of soil borrowed from on-site. Aerial photographs from August 1969, show that landfill operations had commenced by that time.

In 1974, the landfill had expanded in surface area to approximately 300,000 square feet (Figure 4-1). Two geotechnical studies were undertaken for the future expansion of the landfill including the construction of two pond embankments east of the landfill and ground-water, surface water, and leachate collection systems. The pond embankments and collection systems were constructed in 1974.

The west pond (Pond No. 1) embankment was constructed approximately 500 feet east of the 1974 position of the landfill's advancing face (Figure 4-1). The east pond (Pond No. 2) embankment was constructed approximately 1,000 feet east of the west pond embankment. A cutoff trench, set in bedrock, was constructed in the east pond embankment to reduce seepage through the embankment foundation. The embankments and ponds were built to collect and evaporate ground water, surface water, and leachate from the collection systems.

The collection systems consist of a surface water interceptor ditch and a combined leachate and ground-water interceptor system (Figure 4-1). The surface water interceptor ditch was constructed around the exterior of the landfill to direct surface water run-off from outside of the ditch around the landfill. The ditch is V-shaped and approximately three feet deep with steep side slopes.

In 1977, another geotechnical study (Lord and Associates, 1977) was conducted for the expansion of the landfill and for the location of a new borrow area north of the landfill. The field investigation consisted of drilling seventeen test borings; ten at the proposed landfill extension site, five in the proposed borrow area, and two in the existing borrow area.

The west embankment and pond were removed in 1981 to allow eastward expansion of the landfill. Between 1977 and 1981, the leachate collection system was covered with waste as the landfill expanded beyond the limits of the system. Two slurry trenches were constructed in 1981 extending eastward from the ends of the north and south ground-water interceptor ditches (Figure 4-1). These slurry trenches vary in depth from 10 to 25 feet and were designed to be seated in bedrock. The leachate pond (Pond No. 1) can no longer be seen on aerial photographs beginning in the year 1982.

Currently, the landfill is accepting nonhazardous solid waste. Records indicate some hazardous waste was disposed at the landfill, rendering it a RCRA-regulated unit. However, hazardous constituent disposal in the landfill was eliminated in November 1986. As of July 1988, the landfill covered approximately 765,000 square feet of land. In order to reduce wind dispersion and infiltration, approximately three feet of compacted soil has been placed on top of the waste in areas where disposal is no longer occurring.

Sometime after the Present Landfill went into operation in 1968, excess water from the landfill pond was pumped atop a ridge south of the pond. The sprayed water collected on the roadway and flowed into North Walnut Creek. The spraying was moved north of the landfill pond adjacent to the irrigation ditch (SWMU 167.1, Figure 4-1) when this was discovered. The spray water then collected in local drainage channels and flowed around the landfill pond to the main drainage. The spraying was again moved. The final location was south of the west end of the landfill pond adjacent to the pond (Figure 4-1). The excess spray water flowed back into the landfill pond.

The landfill will be closed in accordance with the closure plan presented in the Post-Closure Care Permit Application for Rocky Flats Plant (U.S. DOE, 1988a). Post-closure inspection, maintenance, and monitoring of the Present Landfill will be performed in accordance with 6 CCR 1007-3 Part 264 (40 CFR Part 264).

4.1 SUMMARY OF PREVIOUS INVESTIGATIONS

An alternate ground-water monitoring program is being implemented at the Present Landfill in accordance with 6 CCR 1007-3 and 40 CFR 265.90(d). The CEARP Phase 2 Site Specific Monitoring Plan (U.S. DOE, 1987b), included a plan for the installation and quarterly sampling and analysis of upgradient and downgradient wells. The plan also included the procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain of custody control.

Two alluvial wells (7-86 and 10-86) and two bedrock wells (8-86 and 9-86) were installed at the Present Landfill as part of Plant-wide hydrogeologic site investigations in 1986 (Figure 4-1). Three additional wells (alluvial wells 40-87 and 42-87 and bedrock well 41-87BR) were installed in and around the landfill in 1987 according to the CEARP Phase 2 Site Specific Monitoring Plan. Alluvial wells 58-87, 59-87, 60-87, 61-87, 62-87, 63-87, 64-87, 65-87, 66-87, 67-87, 68-87, 60-87, and 72-87 were also completed in and around the landfill in 1987 to evaluate the performance of the ground-water intercept system and the slurry wall.

Fifteen additional wells were proposed for the Present Landfill Area in the 1988 Annual RCRA Ground-Water Monitoring Report (Rockwell International, 1989a). These wells were proposed to monitor ground-water quality and water levels within the landfill, in sandstone units which subcrop beneath the landfill, and in the weathered claystone. Thirteen wells (B106089, B206189, B206289, B206389, B206489, B206589, B206689, B206789, B206889, B206989, B207089, B207189, and B207289) were actually installed (Figure 4-1). Table 4-1 summarizes the differences between the proposed and actual construction details for the 1989 wells.

Quarterly monitoring of wells at the landfill was initiated immediately upon their completion and development. The 1986 wells were sampled once during 1986 and quarterly during 1987, 1988, and 1989. The 1987 wells were sampled once during 1987 and quarterly during 1988 and 1989. The 1989 wells were sampled once in late September 1989. (The September 1989 samples for the 1989 wells are considered fourth quarter samples.) Ground-water samples were analyzed for the parameters listed in Table 1-2 as discussed in Section 1.1. Water levels were measured monthly as well as at the time of sampling for 1986 and 1987 wells. Water level measurements were obtained in 1989 wells during the week of September 11, 1989 and again at the time of sampling.

4.1.1 Nature and Extent of Ground-water Contamination

Results of hydrogeologic investigations of the Present Landfill suggest that the ground-water intercept system may not completely isolate the landfill from the surrounding ground water. Based upon an examination

TABLE 4-1
PRESENT LANDFILL PROPOSED VERSUS ACTUAL CONSTRUCTION DETAILS FOR THE 1989 MONITORING WELLS

Proposed Well No.	Actual Well No.	Proposed Completion Zone	Actual Completion Zone	Proposed Screen Interval (ft.)	Actual Screen Interval (ft.)	Proposed Total Depth (ft.)	Actual Total Depth (ft.)	Reason(s) for Deviations
LF-01	B106089	Qaf	Qaf	13-20	3.66-23.2	20	24.47	Bedrock at 22.7'; screened landfill debris and alluvium.
LF-02	B206189	Kass(w)	Kacl	28-33	25.9-35.36	33	36.61	Screened 5-15' below alluvium/bedrock contract.
LF-03	B206289	Kass(w)	Kacl	28-33	32.37-41.82	33	43.05	Screened sandy interval from 34.5 to 41.0'; no weathered sandstone encountered.
LF-04	B206389	Qaf	Qrf/Qaf	3-15	4.0-13.5	15	14.74	Bedrock at 13.3; screened bottom 10' of alluvium.
LF-05	B206489	Kass(w)	Qrf/Kass(w)	8-18	3.25-10.0	18	11.35	Encountered subcropping sandstone from 7.5-9.5'; screened alluvium and weathered sandstone.
LF-06	B206589	Kass(w)	Kass(w)	15-25	23.5-35.14	25	36.24	Encountered weathered sandstone form 21.5-34.5'; screened bottom 10' of weathered sandstone.
LF-07	Not Drilled	Qrf	N/A	3.5-13.5	N/A	13.5	N/A	Insufficient Qac for completion.
LF-08	B206689	Kacl	Kacl	14.5-24.5	8.7-18.17	24.5	19.41	Screened 5-15' below alluvium/bedrock contact.
LF-09	B206789	Kass(w)	Kacl	13-23	9.8-19.28	23	20.52	Screened 5-15' below alluvium/bedrock contact; no weathered sandstone encountered.
LF-10	B206889	Qc	Kacl	3.5-10	8.0-17.45	10	18.2	Insufficient colluvium for completion; screened 5-15' below colluvium/bedrock contact.
LF-11	B206989	Kacl	Kacl	6-16	11.8-21.3	16	22.5	Screened 5-15' below alluvium/bedrock contact.
LF-12	B207089	Kass(w)	Kass(w)	32.5-53	31.32-53.00	53	54.00	Encountered weathered sandstone and sandy interval 31.5-60.0'; screened upper 20' of sandy interval/sandstone.

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TABLE 4-1
(continued)
PRESENT LANDFILL PROPOSED VERSUS ACTUAL CONSTRUCTION DETAILS FOR THE 1989 AND PRESENT MONITORING WELLS

Proposed Well No.	Actual Well No.	Proposed Completion Zone	Actual Completion Zone	Proposed Screen Interval (ft.)	Actual Screen Interval (ft.)	Proposed Total Depth (ft.)	Actual Total Depth (ft.)	Reason(s) for Deviations
LF-13	B207189	Kass(u)	Kass(u)	68-78	70.98-75.43	78	77.76	Screened sandy interval from 70.98-75.43' (based on geophysical logging).
LF-14	B207289	Qrf	Kacl	3.5-13.5	5.2-14.65	13.5	15.89	Moved south due to inaccessibility. Insufficient alluvium for completion; screened 5-15' below alluvium/bedrock contact.
LF-15	Not Drilled	Kacl	N/A	14.5-24.5	NA	24.5	N/A	Insufficient Qc for completion.

Qaf: Artificial fill
Qvf: Valley Fill Alluvium
Qrf: Rocky Flats Alluvium
Qc: Colluvium
Kacl: Weathered Bedrock Claystone
Kass(w): Weathered Bedrock Sandstone
Kass(u): Unweathered Bedrock Sandstone

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of alluvial water quality data from wells within and surrounding the landfill, it appeared the landfill contributes calcium, bicarbonate, and to a lesser extent sodium, sulfate, iron, manganese, and strontium to the ground water. Ground water to the north of the north slurry wall had similar concentrations of these analytes, which may be due to the historical spray irrigation operation north and upgradient of this location. With respect to the public health significance of the water quality directly downgradient of the landfill (well 42-87), only iron and manganese exceeded the proposed concentration limits. However, manganese also exceeds the limit (maximum concentration of 0.63 mg/l) in upgradient ground water, and it was not elevated downgradient with respect to upgradient conditions. High salt concentrations further down the drainage (wells 6-86 and 5-86) appear to result from another yet unidentified and presumably natural source.

Bedrock ground-water quality appears to be influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial ground water within the landfill.

4.2 UPPERMOST AQUIFER

The uppermost aquifer in the Present Landfill Area is composed of the saturated surficial materials and weathered bedrock. Rocky Flats Alluvium and artificial fill occur upgradient of and within the landfill; colluvium and North Walnut Creek valley fill alluvium are present downgradient of the Present Landfill (Figure 4-2). In addition, the uppermost aquifer includes weathered claystones of the Arapahoe Formation which crop out or are present beneath the surficial materials within the waste management area. Weathered claystone is included within the definition of the uppermost aquifer because these portions of the Arapahoe Formation are more permeable than unweathered bedrock, and they are in direct contact with the saturated surficial materials within the waste management unit. The depth of weathering varies within the claystone subcrop under this waste management area. Table 4-2 lists the depth of weathering for monitoring wells within the waste management unit.

Arapahoe sandstone is present beneath saturated surficial materials within the waste management unit of the Present Landfill at wells 65-87, 64-87BR, and 70-87 (Figure 4-2). This sandstone is included as part of *the uppermost aquifer.*

TABLE 4-3

PRESENT LANDFILL RESULTS OF HYDRAULIC CONDUCTIVITY TESTS
IN SURFICIAL MATERIALS

Well No.	Formation	Lithology Screened	Drawdown Recovery Test (cm/s)	Slug Tests (cm/s)
45-86	Qrf	Sand and poorly sorted gravel	2.1×10^{-5}	
58-87	Qrf	Sand, poorly sorted gravel, and clayey sand	1.6×10^{-5}	
60-87	Qrf	Sand and gravel grading to clayey sand and clay		1.3×10^{-3}
61-87	Qrf	Sand		9.9×10^{-4}
62-87	Qrf	Sand and gravel, clayey sand and clay		6.2×10^{-4}
63-87	Qrf	Sand and gravel, sandy clay		6.7×10^{-4}
65-87*	Qrf, Kass	Clayey sand, sandstone		4.6×10^{-4}
66-87	Qrf	Sand and sandy clay		1.8×10^{-4}
67-87	Qrf	Clayey sand		6.4×10^{-5}
71-87	Qrf	Clayey sand grading to sandy clay		6.6×10^{-4}
Geometric Mean for Rocky flats Alluvium			1.8×10^{-5}	4.6×10^{-4}

Qrf = Rocky Flats Alluvium

Kass = Arapahoe Sandstone

Geometric Mean for Qrf	1.8×10^{-5}	4.6×10^{-4}

* Completed in two formations. Not used in calculation of geometric mean.

Note: To convert from cm/s to ft/year, multiply by

$$\frac{365.25\ \text{day}}{\text{year}} \times \frac{86400\text{s}}{\text{day}} \times \frac{\text{ft}}{30.48\ \text{cm}}$$

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TABLE 4-4

PRESENT LANDFILL RESULTS OF HYDRAULIC TESTS IN THE ARAPAHOE FORMATION

Well No.	Lithology	Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test* (cm/s)
8-86	Claystone	-	-	5.7×10^{-7}
	Unweathered Sandstone	7×10^{-8}	-	
9-86	Siltstone	-	-	2.0×10^{-8}
	Unweathered Sandstone	4×10^{-8}	-	9.0×10^{-8}
41-87BR	Claystone	-	-	6.7×10^{-7}
	Unweathered Sandstone	-	2.78×10^{-8}	3.1×10^{-7}
B206589BR	Weathered Sandtone	-	5.8×10^{-6} 5.8×10^{-7}	
B207089BR	Weathered Siltstone	-	2.3×10^{-6}	
B207189BR	Unweathered Siltstone	-	1.4×10^{-7} 1.5×10^{-7}	

* Represents geometric mean value from three tests at various intervals

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Along the eastern end of the landfill, slurry trenches have been placed (Figure 4-1). These trenches may also be influencing ground-water flow; future pumping tests are planned to evaluate the effectiveness of the slurry trenches as hydraulic barriers.

The following conclusions regarding the effectiveness of the leachate/ground-water intercept system have been made based on water level and ground-water quality data (U.S. DOE, 1988a).

1) The ground-water intercept system is diverting ground water away from the west end of the landfill.

2) The ground-water intercept system is not diverting ground water away from the north and south sides of the landfill.

3) The clay barrier is holding ground water in the landfill along the west and north sides.

4) The clay barrier is ineffective on the south side of the landfill and is allowing contaminated ground water to leave the landfill at times.

5) The leachate collection system appears to function intermittently on the north side of the landfill.

In general, ground water flows eastwardly in surficial materials toward the landfill pond. This general pattern of ground-water flow is evidenced by the potentiometric surface maps constructed for the first through the fourth quarters, 1989 (Figures 4-3 through 4-6, respectively).

Ground-water flow at the landfill is characterized by relatively little seasonal variation. Fourth quarter 1989 appear to be the driest quarter (Figure 4-6). This is illustrated by three dry wells, 72-87, 40-87, and 42-87) and relatively lower water table elevations. In contrast, the second quarter is the quarter with comparatively higher water table elevations and no dry wells (Figure 4-4).

Nine monitor wells have been completed within weathered bedrock in the Present Landfill Area. In Table 4-5, water levels for these wells are compared to the top of bedrock. Typically, the elevation of the water level is below that of the top of bedrock indicating unsaturated weathered bedrock separates ground water in surficial material from ground water in weathered bedrock. Only at well B206589 does the elevation of the water table exceed that of the top of bedrock (Table 4-5). This indicates that at this location, the weathered bedrock is fully saturated and hydraulically connected to the saturated surficial materials.

TABLE 4-5

PRESENT LANDFILL
ELEVATION OF BEDROCK AND WATER LEVELS IN WELLS
COMPLETED IN WEATHERED BEDROCK

Well	Completion Formation	Top of Bedrock (Elev-ft)	Water Level (Elev-ft)	Date
B206189	Kacl	5963.60	5959.06	09/11/89
			5961.62	09/27/89
B206289	Kacl	5962.79	5944.43	09/12/89
			5947.07	09/28/89
B206589	Kass(w)	5958.30	5960.59	09/12/89
			5960.50	09/21/89
B206689	Kacl	5955.61	5943.12	09/13/89
			5943.96	09/19/89
B206789	Kacl	5923.10	5915.74	09/12/89
			5916.82	09/27/89
B206889	Kacl	5914.09	5902.22	09/11/89
			5902.30	09/18/89
B206989	Kacl	5876.42	5863.77	09/11/89
			5864.00	09/18/88
B207089	Kass(w)	5877.07	5862.25	09/07/89
			5841.02	09/11/89
B207289	Kacl	5948.07	5933.29	09/11/89
			5933.33	09/19/82

Kacl - Weathered Arapahoe claystone

Kass(w) - Weathered Arapahoe sandstone

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Two surficial material/weathered bedrock well pairs were installed at the Present Landfill. A vertical gradient of 1.9 ft/ft downward has been calculated for well pair 64-87/B206189. This vertical gradient is the quotient of the difference in water levels measured on September 11, 1989 and the minimum difference between screened intervals (i.e., the difference between the elevation of the base of the alluvial well 64-87 and the elevation of the top of the screened interval of the weathered bedrock well B206189). No vertical gradient could be calculated at this time for the other well pair 40-87/B206989 because well 40-87 was dry when water level data was available for B206989.

4.4 GROUND-WATER CHEMISTRY AT THE LANDFILL

Ground-water data presented in Appendices E and F show that there are areas of alluvial ground water at the landfill that appear to have elevated concentrations of 1,1,1-TCA, TCE, barium, calcium, iron, magnesium, manganese, sodium, strontium, zinc, sulfate, chloride, TDS, tritium, and uranium. For pre-1989 wells, this assessment is based on second quarter 1989 volatile organics, dissolved metals, and inorganics data, and second quarter 1988 radiochemistry data. Fourth quarter 1989 inorganics data and to a lesser extent dissolved metals and volatile organics data exist for the 1989 wells. The fourth quarter 1989 database is more extensive than that for previous sampling events due to the installation of several 1989 monitoring wells. Therefore, fourth quarter data were used to present TDS concentrations depicted in Figure 4-7.

4.4.1 Alluvial Ground-water Quality Within the Present Landfill

Based on the number and concentration of the inorganic parameters exceeding background, ground water at wells 63-87 and 70-87 within the landfill is most elevated above background, at wells 65-87 and 72-87 is moderately above background, and at wells 58-87, 66-87, 67-87, 71-87, B206089, and B206489 is slightly above background. Ground water at all other wells completed in the Rocky Flats Alluvium does not appear contaminated, although it is noted that nitrate occurs slightly above background in many of these wells including the upgradient well 10-86. Iron and manganese concentrations at well 63-87 are an order of magnitude greater than the proposed concentration limits (5.38 mg/l and 3.9 mg/l, respectively). At both wells 63-87 and 70-87, strontium (0.67 mg/l, 0.64 mg/l), TDS (597 mg/l, 581 mg/l [second quarter 1988]), and total uranium (6.5 pCi/l, 18.4 pCi/l [second quarter 1988]) exceed proposed concentration limits. Although insufficient sample existed for second quarter 1989 radiochemical analysis for well 63-87, and tritium was at background concentrations during the second quarter 1988, tritium concentrations were observed to range from 1800 ± 100 to 2100 ± 100 pCi/l in the first, third, and fourth quarters of 1988, respectively. Zinc and copper exceeded background (background is the proposed concentration limit) in wells 58-87 (zinc only), 66-87, 67-87, 70-87, and 72-87.

Typical of most sanitary landfills, the Present Landfill is observed to impact ground-water quality through increased major ion, iron, manganese, and zinc concentrations. Strontium and copper concentrations are also elevated. Atypical of sanitary landfills, there are areas of elevated uranium and tritium. Landfill contaminants migrate with the flow directly toward the landfill pond and along the leachate collection systems toward the landfill pond.

Generally, volatile organic contamination is low and sporadic in occurrence. 1,1,1-TCA, and TCE were present above detection limits in wells 65-87 and 66-87 during the second quarter, 1989 (Table 4-6). The frequent occurrence of these compounds in other quarters suggest TCE and TCA are contaminants at well 66-87, and TCE is a contaminant at wells 65-87 (and 72-87 based on data from previous quarters).

Methylene chloride, toluene, and $CHCl_3$ were each present in at least one sample from almost every landfill area well in 1988 (including upgradient well 10-86). However, these compounds were also commonly found in the laboratory blanks and were not detected in second quarter 1989 samples from these wells. This suggest these concentrations may represent laboratory contamination.

4.4.2 Downgradient Valley Fill Ground-water Quality

Wells 7-86, 40-87, 42-87, 6-86, and 5-86 are located progressively downgradient of the Present Landfill (Plate 1-1 and Figure 4-1), and are completed in the valley fill material. Except for dissolved metals and volatile organics data for well 42-87, during second quarter 1989 and 1988 these wells were either dry or insufficient sample existed for chemical analysis. The second quarter 1989 dissolved metals and volatile organics data, and the first quarter 1988 inorganic and radionuclide data, indicate ground water at well 42-87 is not contaminated.

TABLE 4-6

PRESENT LANDFILL
VOLATILE ORGANIC COMPOUNDS DETECTED
IN ALLUVIAL GROUND WATER

SECOND QUARTER 1989

Material	WELL	1,1-Dichloro-ethane (ug/l)	1,1,1-Trichloro-ethane (ug/l)	Benzene (ug/l)	Trichloro-ethene (ug/l)	Tetrachloro-ethene (ug/l)	Chloroform (ug/l)	Carbon Tetrachloride (ug/l)
Rocky Flats Alluvium	10-86							
	58-87							
	60-87							
	61-87							
	62-87							
	63-87	4J						
	64-87	Insufficient sample for volatile organic analysis						
	65-87		9		25			
	66-87		7		17			
	67-87							
	68-87							
	70-87							
	71-87	Insufficient sample for volatile organic analysis						
	72-87				37	5J	3J	3J
	B106089	Not sampled 2nd Quarter, 1990						
	B206389	Not sampled 2nd Quarter, 1990						
	B206489	Not sampled 2nd Quarter, 1990						
Valley Fill Alluvium	5-86	Dry						
	6-86	Dry						
	7-86	Insufficient sample for volatile organic analysis						
	40-87							
	42-87							
Weathered Sandstone	B206589	Not sampled 2nd Quarter, 1990						
	B207089	Not sampled 2nd Quarter, 1990						
Weathered Claystone	B206189	Not sampled 2nd Quarter, 1990						
	B206289	Not sampled 2nd Quarter, 1990						
	B206689	Not sampled 2nd Quarter, 1990						
	B206789	Not sampled 2nd Quarter, 1990						
	B206889	Not sampled 2nd Quarter, 1990						
	B206989	Not sampled 2nd Quarter, 1990						
	B207289	Not sampled 2nd Quarter, 1990						
Unweathered Sandstone	8-86	Insuffient sample for volatile organic analysis						
	9-86							
	41-87BR							
	B207189							

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As shown in Appendix E, the high concentrations of analytes at wells 5-86 during the first quarter 1988 are not characteristic of the ground water within or immediately downgradient of the landfill (well 42-87), indicating that another source of high TDS water exists downgradient of the landfill. As no SWMUs are known to be located downgradient of the landfill, this source may be due to natural saline mineral dissolution. Because gross alpha (110 pCi/l), total uranium (169 pCi/l), strontium (7.9 mg/l), sulfate 4125 mg/l), chloride (271 mg/l), and TDS (7430 mg/l), exceed the proposed concentration limits at well 5-86, the source of this ground water is under investigation.

4.4.3 Bedrock Ground-water Quality

4.4.3.1 Weathered Claystone Ground-water Quality

Wells B206189, B206289, B206689, B206789, B206889, B206989, and B207289 were installed in 1989 to monitor ground water within weathered claystone at the Present Landfill. Some fourth quarter 1989 data are available for these wells: inorganics data for wells B206189, B206289, B206689, B206789, and B206989; dissolved metals data for wells B206189 and B206789; and volatile organics data for wells B206689, B206889, and B206989. Well B207289 was dry.

Chloroform was the only volatile organic compound present above detection limits in ground water samples from the weathered claystone. It occurred in the sample from well B206889 (7 ug/l). Because chloroform is not an apparent contaminant of alluvial ground water at the Present Landfill, it is unlikely this datum has significance with respect to contamination characterization.

Inorganics were above background levels in all five wells for which inorganics data are available. The proposed concentration limit for TDS (400 mg/l) was exceeded at wells B206169 (720 mg/l) and B206789 (1200 mg/l), and the proposed concentration limit for sulfate (250 mg/l) was also exceeded at well B206789 (590 mg/l). Chloride did not exceed the proposed concentration limit in any well. Nitrate was elevated above background (0.58 mg/l) at wells B206669 (1.1 mg/l), B206789 (6.3 mg/l), and B206989 (32 mg/l). As nitrate concentrations in alluvial ground water within the landfill are generally below 5 mg/l, further sampling and analysis is required to understand the occurrence of these nitrate levels in weathered bedrock. Nitrate was not elevated in weathered sandstone well B207089 adjacent to well B206989.

Dissolved metals above background in either wells B206189 or B206789 include calcium, lithium, manganese, molybdenum, selenium, sodium, strontium, and zinc. Concentrations of these metals notably exceeding background include lithium in well B206789 (0.2 mg/l; bkg - 0.038 mg/l), molybdenum in well B206189 (0.111 mg/l; bkg - 0.015 mg/l), selenium in well B206789 (0.432 mg/l; bkg - 0.005u mg/l), and sodium in both wells (217 and 130 mg/l, respectively; bkg - 37 mg/l). Elevated molybdenum has been observed in the alluvial ground water at well 64-87 (0.355 mg/l) during first quarter 1988, but molybdenum was below background during the subsequent two quarters. Fourth quarter 1989 dissolved metals data have not yet been received for well 64-87. This information is necessary to better understand the alluvial/bedrock ground water interaction at this location. Additional ground water quality data are necessary to determine the significance of the elevated selenium at well B206789 which significantly exceeds the proposed concentration limit of 0.01 mg/l.

4.4.3.2 Weathered Sandstone Ground-water Quality

Wells B206589 and B207089 were completed in weathered sandstone at the Present Landfill. Only fourth quarter 1989 inorganics data are available for these wells.

Elevated TDS, sulfate, and chloride occur in ground water at both wells. Concentrations are more notable in well B207089 where sulfate (460 mg/l), chloride (520 mg/l), and TDS (1900 mg/l) all exceed the proposed concentration limits (250, 250, and 400 mg/l, respectively). Only TDS exceeds the proposed concentration limit in well B206589 (550 mg/l). Sulfate and TDS in this well are similar in magnitude to the alluvial ground water in this vicinity (well 72-87); however, chloride is considerably higher in the weathered sandstone ground water (57 mg/l) than in the alluvial ground water (<16 mg/l). The alluvium is dry in the vicinity of well B207089 which does not allow such a comparison to be made.

4.4.3.3 Unweathered Sandstone Ground-water Quality

Four bedrock wells completed in unweathered sandstone currently exist to monitor bedrock ground-water quality. Well 9-86 is located immediately west of the landfill; 8-86 is located immediately east of the landfill; and wells 41-87BR and B207189 are downgradient of the landfill embankment in the unnamed tributary of North Walnut Creek. For wells 9-86, 8-86, and 41-87BR, the following assessment is based on second quarter 1989 volatile organics, dissolved metals, and inorganics data, and first quarter 1989 radionuclide data. For well B207189, the assessment is based on fourth quarter 1989 volatile organics, dissolved metals, and inorganics data. Volatile organics were not detected in any of these wells.

Bedrock ground water at wells 41-87 and B207189 is similar in quality and appears to have elevated concentrations of barium, calcium, magnesium (41-87 only), manganese (41-87 only), strontium, chloride, and TDS (41-87 only), while ground-water quality at well 8-87 is within the background tolerance intervals. However, the upgradient bedrock ground water appears to have elevated concentrations of some of these constituents. Well 9-86 has above background concentrations of barium, magnesium, and manganese, suggesting the upper limit background ranges for these constituents is higher than that estimated in the background characterization program. The high concentrations of major ions and metals at wells 41-87 and B207189 are not observed in alluvial ground water within, adjacent to, or immediately downgradient of the landfill. It is concluded that the quality of the ground water in this sandstone, as in the claystone, reflects dissolution of minerals within the sandstone and claystone. The background characterization provides further evidence that, in general, unweathered sandstone ground water has higher salinity than ground water in surficial materials. The concentrations of the above cited metals and inorganics are not notably above background.

4.5 CONTAMINANT MIGRATION RATES

Based on slug tests of wells completed within the landfill (wells 62-87 and 63-87), the hydraulic conductivity of landfill material ranges from 6.2×10^{-4} cm/s to 6.7×10^{-4} cm/s (Table 4-3). Using the maximum hydraulic conductivity of 6.7×10^{-4} cm/s (694 ft/yr), an assumed effective porosity of 0.1, and a horizontal hydraulic gradient of 0.044 ft/ft based on the second quarter 1989 (Figure 4-4), ground water within the landfill is moving at a rate of 305 ft/yr. Thus, approximately five years are required for ground water in the west end of the landfill to reach the landfill pond (1,500 feet). Although hydraulic conductivity values for wells 62-87 and 63-87 are quite similar, fill materials are presumably heterogeneous, and flow conditions no doubt vary considerably within the landfill.

Once ground water within the landfill discharges to the landfill pond, it is retained within the pond where it either evaporates directly from the pond or evaporates via spray irrigation onto the hillside north of the pond. Alluvial ground water from the landfill may reach the valley fill by recharging the ground-water intercept system which can discharge to the unnamed tributary. There are no site-specific hydraulic conductivity data available for valley fill alluvium in the unnamed tributary of Walnut Creek. In addition, the alluvium is dry during portions of the year. Therefore, no ground-water flow rates for unnamed tributary valley fill alluvium have been developed at this time.

4.6 CONCLUSIONS

Hydrogeologic investigation results of the Present Landfill suggest that the ground-water intercept system may not completely isolate the landfill from ground water exterior to the waste management unit. Hydraulic assessments for specific areas on the west, north, and south sides of the ground-water intercept system indicate ground water does migrate into the landfill at the west or northwest and may be exiting the landfill on the southwest at times of the year. However, water balance calculations indicate ground-water inflow probably occurs around the landfill. The intersection of the ground-water intercept system and the slurry walls may be the location of this inflow (U.S. DOE, 1988a).

Based upon an examination of alluvial water quality data from wells within the landfill, it appears the landfill is impacting ground water in discrete locations with major ions, manganese, strontium, iron, tritium and uranium. High salt concentrations further down the drainage (well 5-86) appear to result from another yet unidentified and presumably natural source.

Bedrock ground-water quality is conjectured to be influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial ground water within the landfill.

5.0 REFERENCES

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WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
1086	01/05/88	5996.20	5998.21	2.01	5972.42	13.50	5984.71
1086	02/04/88	5996.20	5998.21	2.01	5972.42	11.60	5986.61
1086	03/14/88	5996.20	5998.21	2.01	5972.42	9.50	5988.71
1086	04/11/88	5996.20	5998.21	2.01	5972.42	8.70	5989.51
1086	05/12/88	5996.20	5998.21	2.01	5972.42	10.20	5988.01
1086	06/15/88	5996.20	5998.21	2.01	5972.42	8.70	5989.51
1086	07/15/88	5996.20	5998.21	2.01	5972.42	9.70	5988.51
1086	08/18/88	5996.20	5998.21	2.01	5972.42	10.50	5987.71
1086	09/15/88	5996.20	5998.21	2.01	5972.42	12.50	5985.71
1086	10/22/88	5996.20	5998.21	2.01	5972.42	13.00	5985.21
1086	11/15/88	5996.20	5998.21	2.01	5972.42	13.70	5984.51
1086	12/15/88	5996.20	5998.21	2.01	5972.42	14.40	5983.81
1086	01/15/89	5996.20	5998.21	2.01	5972.42	15.00	5983.21
1086	02/17/89	5996.20	5998.21	2.01	5972.42	14.30	5983.91
1086	03/03/89	5996.20	5998.21	2.01	5972.42	9.90	5988.31
1086	04/14/89	5996.20	5998.21	2.01	5972.42	11.30	5986.91
1086	05/05/89	5996.20	5998.21	2.01	5972.42	11.70	5986.51
1086	06/15/89	5996.20	5998.21	2.01	5972.42	6.30	5991.91
1086	07/07/89	5996.20	5998.21	2.01	5972.42	10.15	5988.06
1086	08/04/89	5996.20	5998.21	2.01	5972.42	11.65	5986.56
1086	09/11/89	5996.20	5998.21	2.01	5972.42	12.33	5985.88
1086	11/20/89	5996.20	5998.21	2.01	5972.42	14.20	5984.01
5887	01/05/88	5995.10	5996.75	1.65	5972.84	13.00	5983.75
5887	02/04/88	5995.10	5996.75	1.65	5972.84	10.90	5985.85
5887	03/14/88	5995.10	5996.75	1.65	5972.84	9.50	5987.25
5887	04/11/88	5995.10	5996.75	1.65	5972.84	9.20	5987.55
5887	06/15/88	5995.10	5996.75	1.65	5972.84	9.50	5987.25
5887	07/15/88	5995.10	5996.75	1.65	5972.84	10.20	5986.55
5887	08/18/88	5995.10	5996.75	1.65	5972.84	11.00	5985.75
5887	09/15/88	5995.10	5996.75	1.65	5972.84	12.30	5984.45
5887	10/22/88	5995.10	5996.75	1.65	5972.84	13.00	5983.75
5887	11/15/88	5995.10	5996.75	1.65	5972.84	13.60	5983.15
5887	12/15/88	5995.10	5996.75	1.65	5972.84	14.10	5982.65
5887	01/15/89	5995.10	5996.75	1.65	5972.84	14.70	5982.05
5887	02/17/89	5995.10	5996.75	1.65	5972.84	13.30	5983.45
5887	03/03/89	5995.10	5996.75	1.65	5972.84	10.80	5985.95
5887	04/14/89	5995.10	5996.75	1.65	5972.84	11.80	5984.95

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
5887	05/05/89	5995.10	5996.75	1.65	5972.84	11.90	5984.85
5887	06/18/89	5995.10	5996.75	1.65	5972.84	8.20	5988.55
5887	07/07/89	5995.10	5996.75	1.65	5972.84	11.07	5985.68
5887	08/04/89	5995.10	5996.75	1.65	5972.84	12.00	5984.75
5887	09/11/89	5995.10	5996.75	1.65	5972.84	12.16	5984.59
5887	10/25/89	5995.10	5996.75	1.65	5972.84	13.23	5983.52
6087	01/05/88	5984.03	5985.96	1.93	5956.56	12.10	5973.86
6087	02/04/88	5984.03	5985.96	1.93	5956.56	12.20	5973.76
6087	03/14/88	5984.03	5985.96	1.93	5956.56	11.40	5974.56
6087	04/11/88	5984.03	5985.96	1.93	5956.56	10.30	5975.66
6087	05/12/88	5984.03	5985.96	1.93	5956.56	11.60	5974.36
6087	06/15/88	5984.03	5985.96	1.93	5956.56	11.20	5974.76
6087	07/15/88	5984.03	5985.96	1.93	5956.56	12.00	5973.96
6087	08/18/88	5984.03	5985.96	1.93	5956.56	12.40	5973.56
6087	09/15/88	5984.03	5985.96	1.93	5956.56	13.10	5972.86
6087	10/22/88	5984.03	5985.96	1.93	5956.56	13.30	5972.66
6087	11/15/88	5984.03	5985.96	1.93	5956.56	13.70	5972.26
6087	12/15/88	5984.03	5985.96	1.93	5956.56	13.80	5972.16
6087	01/15/89	5984.03	5985.96	1.93	5956.56	14.00	5971.96
6087	02/17/89	5984.03	5985.96	1.93	5956.56	13.90	5972.06
6087	03/03/89	5984.03	5985.96	1.93	5956.56	12.00	5973.96
6087	04/14/89	5984.03	5985.96	1.93	5956.56	12.20	5973.76
6087	05/05/89	5984.03	5985.96	1.93	5956.56	13.00	5972.96
6087	06/16/89	5984.03	5985.96	1.93	5956.56	10.50	5975.46
6087	07/07/89	5984.03	5985.96	1.93	5956.56	12.65	5973.31
6087	08/04/89	5984.03	5985.96	1.93	5956.56	13.26	5972.70
6087	09/11/89	5984.03	5985.96	1.93	5956.56	13.41	5972.55
6087	10/26/89	5984.03	5985.96	1.93	5956.56	13.70	5972.26
6187	01/06/88	5984.00	5985.75	1.75	5955.76	13.00	5972.75
6187	02/04/88	5984.00	5985.75	1.75	5955.76	12.30	5973.45
6187	03/21/88	5984.00	5985.75	1.75	5955.76	11.80	5973.95
6187	04/11/88	5984.00	5985.75	1.75	5955.76	12.70	5973.05
6187	05/12/88	5984.00	5985.75	1.75	5955.76	11.80	5973.95
6187	06/15/88	5984.00	5985.75	1.75	5955.76	11.30	5974.45
6187	07/15/88	5984.00	5985.75	1.75	5955.76	11.90	5973.85
6187	08/18/88	5984.00	5985.75	1.75	5955.76	12.30	5973.45
6187	09/15/88	5984.00	5985.75	1.75	5955.76	12.90	5972.85

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
6187	10/22/88	5984.00	5985.75	1.75	5955.76	13.00	5972.75
6187	11/15/88	5984.00	5985.75	1.75	5955.76	13.50	5972.25
6187	12/15/88	5984.00	5985.75	1.75	5955.76	13.60	5972.15
6187	01/15/89	5984.00	5985.75	1.75	5955.76	13.90	5971.85
6187	02/17/89	5984.00	5985.75	1.75	5955.76	13.70	5972.05
6187	03/08/89	5984.00	5985.75	1.75	5955.76	12.60	5973.15
6187	04/14/89	5984.00	5985.75	1.75	5955.76	12.50	5973.25
6187	05/05/89	5984.00	5985.75	1.75	5955.76	12.20	5973.55
6187	06/16/89	5984.00	5985.75	1.75	5955.76	10.90	5974.85
6187	07/14/89	5984.00	5985.75	1.75	5955.76	12.65	5973.10
6187	08/11/89	5984.00	5985.75	1.75	5955.76	13.18	5972.57
6187	09/12/89	5984.00	5985.75	1.75	5955.76	13.19	5972.56
6187	11/01/89	5984.00	5985.75	1.75	5955.76	13.67	5972.08
6287	01/06/88	5984.16	5986.36	2.20	5957.60	14.10	5972.26
6287	02/04/88	5984.16	5986.36	2.20	5957.60	13.60	5972.76
6287	03/21/88	5984.16	5986.36	2.20	5957.60	13.20	5973.16
6287	04/11/88	5984.16	5986.36	2.20	5957.60	13.70	5972.66
6287	05/12/88	5984.16	5986.36	2.20	5957.60	2.00	5984.36
6287	06/15/88	5984.16	5986.36	2.20	5957.60	12.70	5973.66
6287	07/15/88	5984.16	5986.36	2.20	5957.60	13.20	5973.16
6287	07/15/88	5984.16	5986.36	2.20	5957.60	15.20	5971.16
6287	08/18/88	5984.16	5986.36	2.20	5957.60	13.60	5972.76
6287	09/15/88	5984.16	5986.36	2.20	5957.60	14.10	5972.26
6287	10/22/88	5984.16	5986.36	2.20	5957.60	14.30	5972.06
6287	10/22/88	5984.16	5986.36	2.20	5957.60	15.60	5970.76
6287	11/15/88	5984.16	5986.36	2.20	5957.60	14.70	5971.66
6287	11/15/88	5984.16	5986.36	2.20	5957.60	15.90	5970.46
6287	12/15/88	5984.16	5986.36	2.20	5957.60	14.60	5971.76
6287	01/15/89	5984.16	5986.36	2.20	5957.60	15.00	5971.36
6287	02/17/89	5984.16	5986.36	2.20	5957.60	14.80	5971.56
6287	03/08/89	5984.16	5986.36	2.20	5957.60	14.00	5972.36
6287	04/14/89	5984.16	5986.36	2.20	5957.60	13.90	5972.46
6287	05/05/89	5984.16	5986.36	2.20	5957.60	13.50	5972.86
6287	06/16/89	5984.16	5986.36	2.20	5957.60	12.20	5974.16
6287	07/14/89	5984.16	5986.36	2.20	5957.60	13.85	5972.51
6287	08/11/89	5984.16	5986.36	2.20	5957.60	14.38	5971.98
6287	09/12/89	5984.16	5986.36	2.20	5957.60	14.27	5972.09
6287	11/02/89	5984.16	5986.36	2.20	5957.60	14.75	5971.61

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
6387	01/06/88	5985.42	5987.06	1.64	5960.02	DRY	DRY
6387	02/04/88	5985.42	5987.06	1.64	5960.02	15.30	5971.76
6387	03/21/88	5985.42	5987.06	1.64	5960.02	15.10	5971.96
6387	04/11/88	5985.42	5987.06	1.64	5960.02	15.20	5971.86
6387	05/12/88	5985.42	5987.06	1.64	5960.02	15.00	5972.06
6387	06/15/88	5985.42	5987.06	1.64	5960.02	15.00	5972.06
6387	08/18/88	5985.42	5987.06	1.64	5960.02	15.30	5971.76
6387	09/15/88	5985.42	5987.06	1.64	5960.02	15.60	5971.46
6387	12/15/88	5985.42	5987.06	1.64	5960.02	16.00	5971.06
6387	01/15/89	5985.42	5987.06	1.64	5960.02	16.30	5970.76
6387	02/17/89	5985.42	5987.06	1.64	5960.02	16.30	5970.76
6387	03/10/89	5985.42	5987.06	1.64	5960.02	16.30	5970.76
6387	04/14/89	5985.42	5987.06	1.64	5960.02	16.30	5970.76
6387	05/05/89	5985.42	5987.06	1.64	5960.02	16.20	5970.86
6387	06/16/89	5985.42	5987.06	1.64	5960.02	15.80	5971.26
6387	07/14/89	5985.42	5987.06	1.64	5960.02	16.05	5971.01
6387	08/11/89	5985.42	5987.06	1.64	5960.02	16.26	5970.80
6387	09/12/89	5985.42	5987.06	1.64	5960.02	16.33	5970.73
6387	11/02/89	5985.42	5987.06	1.64	5960.02	16.44	5970.62
6487	01/09/88	5985.89	5987.33	1.44	5962.59	7.50	5979.83
6487	02/04/88	5985.89	5987.33	1.44	5962.59	17.60	5969.73
6487	02/24/88	5985.89	5987.33	1.44	5962.59	6.90	5980.43
6487	03/07/88	5985.89	5987.33	1.44	5962.59	6.80	5980.53
6487	03/21/88	5985.89	5987.33	1.44	5962.59	17.90	5969.43
6487	04/04/88	5985.89	5987.33	1.44	5962.59	6.70	5980.63
6487	04/11/88	5985.89	5987.33	1.44	5962.59	18.20	5969.13
6487	05/02/88	5985.89	5987.33	1.44	5962.59	6.90	5980.43
6487	05/12/88	5985.89	5987.33	1.44	5962.59	18.40	5968.93
6487	06/15/88	5985.89	5987.33	1.44	5962.59	17.10	5970.23
6487	07/15/88	5985.89	5987.33	1.44	5962.59	17.10	5970.23
6487	08/18/88	5985.89	5987.33	1.44	5962.59	17.40	5969.93
6487	09/15/88	5985.89	5987.33	1.44	5962.59	20.80	5966.53
6487	09/15/88	5985.89	5987.33	1.44	5962.59	13.60	5973.73
6487	10/22/88	5985.89	5987.33	1.44	5962.59	19.20	5968.13
6487	11/15/88	5985.89	5987.33	1.44	5962.59	19.70	5967.63
6487	12/15/88	5985.89	5987.33	1.44	5962.59	19.70	5967.63
6487	01/15/89	5985.89	5987.33	1.44	5962.59	20.10	5967.23
6487	02/17/89	5985.89	5987.33	1.44	5962.59	20.30	5967.03

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
6487	03/08/89	5985.89	5987.33	1.44	5962.59	20.40	5966.93
6487	04/14/89	5985.89	5987.33	1.44	5962.59	20.50	5966.83
6487	05/05/89	5985.89	5987.33	1.44	5962.59	20.70	5966.63
6487	09/11/89	5985.89	5987.33	1.44	5962.59	20.56	5966.77
6487	11/06/89	5985.89	5987.33	1.44	5962.59	20.72	5966.61
6587	01/06/88	5983.08	5985.02	1.94	5959.12	14.50	5970.52
6587	02/04/88	5983.08	5985.02	1.94	5959.12	13.20	5971.82
6587	03/21/88	5983.08	5985.02	1.94	5959.12	13.10	5971.92
6587	04/11/88	5983.08	5985.02	1.94	5959.12	12.40	5972.62
6587	05/12/88	5983.08	5985.02	1.94	5959.12	13.00	5972.02
6587	06/15/88	5983.08	5985.02	1.94	5959.12	12.40	5972.62
6587	07/15/88	5983.08	5985.02	1.94	5959.12	12.80	5972.22
6587	08/18/88	5983.08	5985.02	1.94	5959.12	13.20	5971.82
6587	10/22/88	5983.08	5985.02	1.94	5959.12	14.30	5970.72
6587	11/15/88	5983.08	5985.02	1.94	5959.12	15.30	5969.72
6587	12/15/88	5983.08	5985.02	1.94	5959.12	15.30	5969.72
6587	01/15/89	5983.08	5985.02	1.94	5959.12	15.90	5969.12
6587	02/17/89	5983.08	5985.02	1.94	5959.12	15.50	5969.52
6587	03/08/89	5983.08	5985.02	1.94	5959.12	13.10	5971.92
6587	04/14/89	5983.08	5985.02	1.94	5959.12	13.10	5971.92
6587	05/05/89	5983.08	5985.02	1.94	5959.12	12.80	5972.22
6587	06/16/89	5983.08	5985.02	1.94	5959.12	11.30	5973.72
6587	09/11/89	5983.08	5985.02	1.94	5959.12	14.07	5970.95
6587	11/07/89	5983.08	5985.02	1.94	5959.12	14.54	5970.48
6687	01/05/88	5981.90	5983.64	1.74	5963.94	13.00	5970.64
6687	02/04/88	5981.90	5983.64	1.74	5963.94	11.90	5971.74
6687	03/14/88	5981.90	5983.64	1.74	5963.94	11.50	5972.14
6687	04/11/88	5981.90	5983.64	1.74	5963.94	10.90	5972.74
6687	05/12/88	5981.90	5983.64	1.74	5963.94	11.70	5971.94
6687	06/15/88	5981.90	5983.64	1.74	5963.94	11.00	5972.64
6687	07/15/88	5981.90	5983.64	1.74	5963.94	11.50	5972.14
6687	08/18/88	5981.90	5983.64	1.74	5963.94	11.90	5971.74
6687	09/15/88	5981.90	5983.64	1.74	5963.94	12.30	5971.34
6687	10/22/88	5981.90	5983.64	1.74	5963.94	12.90	5970.74
6687	11/15/88	5981.90	5983.64	1.74	5963.94	13.90	5969.74
6687	12/15/88	5981.90	5983.64	1.74	5963.94	14.00	5969.64
6687	01/15/89	5981.90	5983.64	1.74	5963.94	14.40	5969.24

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
6687	02/17/89	5981.90	5983.64	1.74	5963.94	14.20	5969.44
6687	03/03/89	5981.90	5983.64	1.74	5963.94	11.00	5972.64
6687	04/14/89	5981.90	5983.64	1.74	5963.94	11.60	5972.04
6687	05/05/89	5981.90	5983.64	1.74	5963.94	11.70	5971.94
6687	06/16/89	5981.90	5983.64	1.74	5963.94	9.70	5973.94
6687	07/07/89	5981.90	5983.64	1.74	5963.94	11.89	5971.75
6687	08/04/89	5981.90	5983.64	1.74	5963.94	12.63	5971.01
6687	09/12/89	5981.90	5983.64	1.74	5963.94	12.32	5971.32
6687	11/03/89	5981.90	5983.64	1.74	5963.94	13.10	5970.54
6787	01/06/88	5969.50	5971.72	2.22	5953.04	4.30	5967.42
6787	02/04/88	5969.50	5971.72	2.22	5953.04	10.40	5961.32
6787	03/21/88	5969.50	5971.72	2.22	5953.04	10.00	5961.72
6787	04/11/88	5969.50	5971.72	2.22	5953.04	9.90	5961.82
6787	05/12/88	5969.50	5971.72	2.22	5953.04	10.10	5961.62
6787	06/15/88	5969.50	5971.72	2.22	5953.04	10.20	5961.52
6787	07/15/88	5969.50	5971.72	2.22	5953.04	10.70	5961.02
6787	08/18/88	5969.50	5971.72	2.22	5953.04	11.00	5960.72
6787	09/15/88	5969.50	5971.72	2.22	5953.04	11.50	5960.22
6787	10/22/88	5969.50	5971.72	2.22	5953.04	11.50	5960.22
6787	11/15/88	5969.50	5971.72	2.22	5953.04	11.70	5960.02
6787	12/15/88	5969.50	5971.72	2.22	5953.04	11.70	5960.02
6787	01/15/89	5969.50	5971.72	2.22	5953.04	11.60	5960.12
6787	02/17/89	5969.50	5971.72	2.22	5953.04	11.30	5960.42
6787	03/08/89	5969.50	5971.72	2.22	5953.04	8.80	5962.92
6787	04/14/89	5969.50	5971.72	2.22	5953.04	9.70	5962.02
6787	05/05/89	5969.50	5971.72	2.22	5953.04	9.80	5961.92
6787	06/16/89	5969.50	5971.72	2.22	5953.04	9.00	5962.72
6787	07/07/89	5969.50	5971.72	2.22	5953.04	10.61	5961.11
6787	08/11/89	5969.50	5971.72	2.22	5953.04	11.58	5960.14
6787	09/11/89	5969.50	5971.72	2.22	5953.04	11.15	5960.57
6787	11/08/89	5969.50	5971.72	2.22	5953.04	11.75	5959.97
6887	01/06/88	5968.48	5970.31	1.83	5952.73	9.80	5960.51
6887	02/04/88	5968.48	5970.31	1.83	5952.73	9.10	5961.21
6887	03/21/88	5968.48	5970.31	1.83	5952.73	8.80	5961.51
6887	04/11/88	5968.48	5970.31	1.83	5952.73	8.20	5962.11
6887	05/12/88	5968.48	5970.31	1.83	5952.73	8.80	5961.51
6887	06/15/88	5968.48	5970.31	1.83	5952.73	8.80	5961.51

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
6887	07/15/88	5968.48	5970.31	1.83	5952.73	9.40	5960.91
6887	08/18/88	5968.48	5970.31	1.83	5952.73	9.70	5960.61
6887	09/15/88	5968.48	5970.31	1.83	5952.73	10.20	5960.11
6887	10/22/88	5968.48	5970.31	1.83	5952.73	10.10	5960.21
6887	11/15/88	5968.48	5970.31	1.83	5952.73	10.40	5959.91
6887	12/15/88	5968.48	5970.31	1.83	5952.73	10.40	5959.91
6887	01/15/89	5968.48	5970.31	1.83	5952.73	10.30	5960.01
6887	02/17/89	5968.48	5970.31	1.83	5952.73	10.00	5960.31
6887	03/08/89	5968.48	5970.31	1.83	5952.73	7.50	5962.81
6887	04/14/89	5968.48	5970.31	1.83	5952.73	8.50	5961.81
6887	05/05/89	5968.48	5970.31	1.83	5952.73	8.60	5961.71
6887	06/18/89	5968.48	5970.31	1.83	5952.73	7.80	5962.51
6887	07/07/89	5968.48	5970.31	1.83	5952.73	9.32	5960.99
6887	08/11/89	5968.48	5970.31	1.83	5952.73	10.27	5960.04
6887	09/11/89	5968.48	5970.31	1.83	5952.73	9.86	5960.45
6887	11/09/89	5968.48	5970.31	1.83	5952.73	10.53	5959.78
7087	01/06/88	5966.30	5968.35	2.05	5950.04	DRY	DRY
7087	02/04/88	5966.30	5968.35	2.05	5950.04	DRY	DRY
7087	03/21/88	5966.30	5968.35	2.05	5950.04	DRY	DRY
7087	04/11/88	5966.30	5968.35	2.05	5950.04	9.40	5958.95
7087	05/12/88	5966.30	5968.35	2.05	5950.04	8.10	5960.25
7087	06/15/88	5966.30	5968.35	2.05	5950.04	8.50	5959.85
7087	07/15/88	5966.30	5968.35	2.05	5950.04	8.80	5959.55
7087	08/18/88	5966.30	5968.35	2.05	5950.04	9.20	5959.15
7087	10/22/88	5966.30	5968.35	2.05	5950.04	9.80	5958.55
7087	11/15/88	5966.30	5968.35	2.05	5950.04	10.70	5957.65
7087	12/15/88	5966.30	5968.35	2.05	5950.04	10.80	5957.55
7087	01/15/89	5966.30	5968.35	2.05	5950.04	9.80	5958.55
7087	02/17/89	5966.30	5968.35	2.05	5950.04	9.70	5958.65
7087	03/08/89	5966.30	5968.35	2.05	5950.04	7.50	5960.85
7087	04/14/89	5966.30	5968.35	2.05	5950.04	8.20	5960.15
7087	05/05/89	5966.30	5968.35	2.05	5950.04	7.60	5960.75
7087	06/18/89	5966.30	5968.35	2.05	5950.04	7.50	5960.85
7087	07/07/89	5966.30	5968.35	2.05	5950.04	8.88	5959.47
7087	08/04/89	5966.30	5968.35	2.05	5950.04	10.08	5958.27
7087	09/12/89	5966.30	5968.35	2.05	5950.04	10.78	5957.57
7087	11/28/89	5966.30	5968.35	2.05	5950.04	11.65	5956.70

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
7187	01/05/88	5963.39	5965.47	2.08	5949.82	7.10	5958.37
7187	02/04/88	5963.39	5965.47	2.08	5949.82	6.70	5958.77
7187	03/14/88	5963.39	5965.47	2.08	5949.82	6.40	5959.07
7187	04/11/88	5963.39	5965.47	2.08	5949.82	6.00	5959.47
7187	05/12/88	5963.39	5965.47	2.08	5949.82	7.10	5958.37
7187	06/15/88	5963.39	5965.47	2.08	5949.82	7.80	5957.67
7187	07/15/88	5963.39	5965.47	2.08	5949.82	8.00	5957.47
7187	08/18/88	5963.39	5965.47	2.08	5949.82	8.50	5956.97
7187	09/15/88	5963.39	5965.47	2.08	5949.82	8.50	5956.97
7187	10/22/88	5963.39	5965.47	2.08	5949.82	8.40	5957.07
7187	11/15/88	5963.39	5965.47	2.08	5949.82	8.20	5957.27
7187	12/15/88	5963.39	5965.47	2.08	5949.82	8.10	5957.37
7187	01/15/89	5963.39	5965.47	2.08	5949.82	7.80	5957.67
7187	02/17/89	5963.39	5965.47	2.08	5949.82	7.40	5958.07
7187	03/03/89	5963.39	5965.47	2.08	5949.82	6.00	5959.47
7187	04/14/89	5963.39	5965.47	2.08	5949.82	6.10	5959.37
7187	05/05/89	5963.39	5965.47	2.08	5949.82	5.80	5959.67
7187	09/13/89	5963.39	5965.47	2.08	5949.82	8.23	5957.24
7187	10/26/89	5963.39	5965.47	2.08	5949.82	8.10	5957.37
7287	01/06/88	5969.11	5971.18	2.07	5960.35	6.00	5965.18
7287	02/04/88	5969.11	5971.18	2.07	5960.35	5.00	5966.18
7287	03/14/88	5969.11	5971.18	2.07	5960.35	4.70	5966.48
7287	04/11/88	5969.11	5971.18	2.07	5960.35	4.20	5966.98
7287	05/12/88	5969.11	5971.18	2.07	5960.35	57.00	5914.18
7287	06/15/88	5969.11	5971.18	2.07	5960.35	6.20	5964.98
7287	07/15/88	5969.11	5971.18	2.07	5960.35	6.80	5964.38
7287	08/18/88	5969.11	5971.18	2.07	5960.35	7.50	5963.68
7287	09/15/88	5969.11	5971.18	2.07	5960.35	7.60	5963.58
7287	10/22/88	5969.11	5971.18	2.07	5960.35	7.90	5963.28
7287	11/15/88	5969.11	5971.18	2.07	5960.35	DRY	DRY
7287	12/15/88	5969.11	5971.18	2.07	5960.35	8.30	5962.88
7287	01/15/89	5969.11	5971.18	2.07	5960.35	7.60	5963.58
7287	02/17/89	5969.11	5971.18	2.07	5960.35	6.70	5964.48
7287	03/08/89	5969.11	5971.18	2.07	5960.35	5.20	5965.98
7287	04/14/89	5969.11	5971.18	2.07	5960.35	4.70	5966.48
7287	05/05/89	5969.11	5971.18	2.07	5960.35	5.20	5965.98
7287	06/16/89	5969.11	5971.18	2.07	5960.35	4.50	5966.68
7287	07/07/89	5969.11	5971.18	2.07	5960.35	6.72	5964.46

WATER LEVEL SUMMARY

LANDFILL ROCKY FLATS ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
7287	08/04/89	5969.11	5971.18	2.07	5960.35	7.62	5963.56
7287	09/12/89	5969.11	5971.18	2.07	5960.35	6.18	5965.00
7287	12/14/89	5969.11	5971.18	2.07	5960.35	DRY	DRY
B106089	02/02/89	5993.30	5995.35	2.05	5970.10	22.25	5973.10
B106089	09/11/89	5993.30	5995.35	2.05	5970.10	22.30	5973.05
B106089	10/13/89	5993.30	5995.35	2.05	5970.10	22.24	5973.11
B206389	09/12/89	5969.70	5971.56	1.86	5956.20	16.00	5955.56
B206389	09/28/89	5969.70	5971.56	1.86	5956.20	15.79	5955.77
B206489	09/12/89	5969.14	5971.46	2.32	5959.14	10.07	5961.39
B206489	09/27/89	5969.14	5971.46	2.32	5959.14	7.24	5964.22

WATER LEVEL SUMMARY

LANDFILL VALLEY FILL ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
0586	01/06/88	5720.07	5722.61	2.54	5710.31	10.50	5712.11
0586	02/24/88	5720.07	5722.61	2.54	5710.31	6.60	5716.01
0586	03/14/88	5720.07	5722.61	2.54	5710.31	4.90	5717.71
0586	04/11/88	5720.07	5722.61	2.54	5710.31	4.70	5717.91
0586	05/12/88	5720.07	5722.61	2.54	5710.31	7.90	5714.71
0586	06/15/88	5720.07	5722.61	2.54	5710.31	9.00	5713.61
0586	07/15/88	5720.07	5722.61	2.54	5710.31	9.70	5712.91
0586	08/18/88	5720.07	5722.61	2.54	5710.31	9.90	5712.71
0586	09/15/88	5720.07	5722.61	2.54	5710.31	10.40	5712.21
0586	10/22/88	5720.07	5722.61	2.54	5710.31	10.50	5712.11
0586	11/15/88	5720.07	5722.61	2.54	5710.31	10.80	5711.81
0586	12/15/88	5720.07	5722.61	2.54	5710.31	10.80	5711.81
0586	01/15/89	5720.07	5722.61	2.54	5710.31	10.90	5711.71
0586	02/27/89	5720.07	5722.61	2.54	5710.31	10.70	5711.91
0586	03/10/89	5720.07	5722.61	2.54	5710.31	10.50	5712.11
0586	04/25/89	5720.07	5722.61	2.54	5710.31	10.30	5712.31
0586	05/05/89	5720.07	5722.61	2.54	5710.31	10.30	5712.31
0586	06/18/89	5720.07	5722.61	2.54	5710.31	8.20	5714.41
0586	07/14/89	5720.07	5722.61	2.54	5710.31	9.40	5713.21
0586	08/11/89	5720.07	5722.61	2.54	5710.31	11.28	5711.33
0586	09/12/89	5720.07	5722.61	2.54	5710.31	11.77	5710.84
0586	12/14/89	5720.07	5722.61	2.54	5710.31	11.48	5711.13
0686	01/06/88	5806.10	5808.58	2.48	5797.22	3.30	5805.28
0686	02/04/88	5806.10	5808.58	2.48	5797.22	10.20	5798.38
0686	03/14/88	5806.10	5808.58	2.48	5797.22	10.10	5798.48
0686	04/11/88	5806.10	5808.58	2.48	5797.22	4.50	5804.08
0686	05/12/88	5806.10	5808.58	2.48	5797.22	5.40	5803.18
0686	06/15/88	5806.10	5808.58	2.48	5797.22	7.90	5800.68
0686	07/15/88	5806.10	5808.58	2.48	5797.22	8.00	5800.58
0686	08/18/88	5806.10	5808.58	2.48	5797.22	8.20	5800.38
0686	09/15/88	5806.10	5808.58	2.48	5797.22	8.70	5799.88
0686	10/22/88	5806.10	5808.58	2.48	5797.22	8.90	5799.68
0686	11/15/88	5806.10	5808.58	2.48	5797.22	9.30	5799.28
0686	12/15/88	5806.10	5808.58	2.48	5797.22	9.30	5799.28
0686	01/15/89	5806.10	5808.58	2.48	5797.22	9.90	5798.68
0686	02/27/89	5806.10	5808.58	2.48	5797.22	8.00	5800.58
0686	03/10/89	5806.10	5808.58	2.48	5797.22	DRY	DRY

WATER LEVEL SUMMARY

LANDFILL VALLEY FILL ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
0686	04/14/89	5806.10	5808.58	2.48	5797.22	DRY	DRY
0686	05/05/89	5806.10	5808.58	2.48	5797.22	9.20	5799.38
0686	06/16/89	5806.10	5808.58	2.48	5797.22	11.20	5797.38
0686	07/14/89	5806.10	5808.58	2.48	5797.22	9.65	5798.93
0686	08/11/89	5806.10	5808.58	2.48	5797.22	10.14	5798.44
0686	09/12/89	5806.10	5808.58	2.48	5797.22	10.40	5798.18
0686	11/16/89	5806.10	5808.58	2.48	5797.22	DRY	DRY
0786	01/06/88	5924.46	5926.52	2.06	5918.72	4.80	5921.72
0786	02/04/88	5924.46	5926.52	2.06	5918.72	4.80	5921.72
0786	03/21/88	5924.46	5926.52	2.06	5918.72	4.70	5921.82
0786	04/11/88	5924.46	5926.52	2.06	5918.72	4.90	5921.62
0786	05/12/88	5924.46	5926.52	2.06	5918.72	5.20	5921.32
0786	06/15/88	5924.46	5926.52	2.06	5918.72	6.50	5920.02
0786	07/15/88	5924.46	5926.52	2.06	5918.72	7.00	5919.52
0786	08/18/88	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	09/15/88	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	10/22/88	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	11/15/88	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	12/15/88	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	01/15/89	5924.46	5926.52	2.06	5918.72	6.00	5920.52
0786	02/17/89	5924.46	5926.52	2.06	5918.72	5.90	5920.62
0786	03/08/89	5924.46	5926.52	2.06	5918.72	5.20	5921.32
0786	04/14/89	5924.46	5926.52	2.06	5918.72	5.60	5920.92
0786	05/05/89	5924.46	5926.52	2.06	5918.72	5.70	5920.82
0786	09/12/89	5924.46	5926.52	2.06	5918.72	DRY	DRY
0786	12/14/89	5924.46	5926.52	2.06	5918.72	5.76	5920.76
4087	01/06/88	5882.69	5884.69	2.00	5876.23	7.60	5877.09
4087	02/04/88	5882.69	5884.69	2.00	5876.23	7.50	5877.19
4087	03/14/88	5882.69	5884.69	2.00	5876.23	6.20	5878.49
4087	04/11/88	5882.69	5884.69	2.00	5876.23	5.30	5879.39
4087	05/12/88	5882.69	5884.69	2.00	5876.23	4.40	5880.29
4087	06/15/88	5882.69	5884.69	2.00	5876.23	7.20	5877.49
4087	07/15/88	5882.69	5884.69	2.00	5876.23	6.80	5877.89
4087	08/18/88	5882.69	5884.69	2.00	5876.23	7.20	5877.49
4087	09/15/88	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	10/22/88	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	11/15/88	5882.69	5884.69	2.00	5876.23	DRY	DRY

WATER LEVEL SUMMARY

LANDFILL VALLEY FILL ALLUVIUM

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
4087	12/15/88	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	01/15/89	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	02/17/89	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	03/03/89	5882.69	5884.69	2.00	5876.23	8.10	5876.59
4087	04/14/89	5882.69	5884.69	2.00	5876.23	8.00	5876.69
4087	05/05/89	5882.69	5884.69	2.00	5876.23	4.80	5879.89
4087	06/16/89	5882.69	5884.69	2.00	5876.23	3.80	5880.89
4087	07/07/89	5882.69	5884.69	2.00	5876.23	6.05	5878.64
4087	08/04/89	5882.69	5884.69	2.00	5876.23	8.03	5876.66
4087	09/11/89	5882.69	5884.69	2.00	5876.23	DRY	DRY
4087	11/08/89	5882.69	5884.69	2.00	5876.23	DRY	DRY
4287	01/06/88	5854.05	5855.93	1.88	5847.69	3.20	5852.73
4287	02/04/88	5854.05	5855.93	1.88	5847.69	3.30	5852.63
4287	03/14/88	5854.05	5855.93	1.88	5847.69	3.30	5852.63
4287	04/11/88	5854.05	5855.93	1.88	5847.69	3.50	5852.43
4287	05/12/88	5854.05	5855.93	1.88	5847.69	4.10	5851.83
4287	06/15/88	5854.05	5855.93	1.88	5847.69	6.10	5849.83
4287	07/15/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	08/18/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	09/15/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	10/22/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	11/15/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	12/15/88	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	01/15/89	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	02/27/89	5854.05	5855.93	1.88	5847.69	3.30	5852.63
4287	03/10/89	5854.05	5855.93	1.88	5847.69	3.10	5852.83
4287	04/14/89	5854.05	5855.93	1.88	5847.69	3.50	5852.43
4287	05/05/89	5854.05	5855.93	1.88	5847.69	3.50	5852.43
4287	06/16/89	5854.05	5855.93	1.88	5847.69	3.40	5852.53
4287	07/14/89	5854.05	5855.93	1.88	5847.69	6.36	5849.57
4287	08/11/89	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	09/12/89	5854.05	5855.93	1.88	5847.69	DRY	DRY
4287	10/26/89	5854.05	5855.93	1.88	5847.69	DRY	DRY

WATER LEVEL SUMMARY

LANDFILL WEATHERED CLAYSTONE

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
B206189	09/11/89	5984.50	5986.57	2.07	5949.14	27.51	5959.06
B206189	09/27/89	5984.50	5986.57	2.07	5949.14	24.95	5961.62
B206289	01/17/89	5977.59	5979.49	1.90	5935.77	24.15	5955.34
B206289	09/12/89	5977.59	5979.49	1.90	5935.77	35.06	5944.43
B206289	09/28/89	5977.59	5979.49	1.90	5935.77	32.42	5947.07
B206689	09/13/89	5959.31	5961.20	1.89	5941.14	18.08	5943.12
B206689	09/19/89	5959.31	5961.20	1.89	5941.14	17.24	5943.96
B206789	09/12/89	5927.90	5930.19	2.29	5908.62	14.45	5915.74
B206789	09/27/89	5927.90	5930.19	2.29	5908.62	13.37	5916.82
B206889	09/11/89	5917.09	5919.15	2.06	5899.64	16.93	5902.22
B206889	09/18/89	5917.09	5919.15	2.06	5899.64	16.85	5902.30
B206989	09/11/89	5882.42	5884.32	1.90	5861.12	20.55	5863.77
B206989	09/18/89	5882.42	5884.32	1.90	5861.12	20.32	5864.00
B207289	09/11/89	5948.27	5950.49	2.22	5933.62	17.20	5933.29
B207289	09/19/89	5948.27	5950.49	2.22	5933.62	17.16	5933.33

WATER LEVEL SUMMARY

LANDFILL WEATHERED SANDSTONE

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
B206589	09/12/89	5967.80	5969.72	1.92	5932.66	9.13	5960.59
B206589	09/21/89	5967.80	5969.72	1.92	5932.66	9.22	5960.50
B207089	09/07/89	5883.07	5884.95	1.88	5830.07	22.70	5862.25
B207089	09/11/89	5883.07	5884.95	1.88	5830.07	43.93	5841.02

WATER LEVEL SUMMARY

LANDFILL UNWEATHERED SANDSTONE

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
0886	01/06/88	5925.03	5926.83	1.80	5861.24	32.20	5894.63
0886	02/04/88	5925.03	5926.83	1.80	5861.24	59.50	5867.33
0886	03/21/88	5925.03	5926.83	1.80	5861.24	30.30	5896.53
0886	04/11/88	5925.03	5926.83	1.80	5861.24	23.80	5903.03
0886	05/12/88	5925.03	5926.83	1.80	5861.24	18.00	5908.83
0886	06/15/88	5925.03	5926.83	1.80	5861.24	60.00	5866.83
0886	07/15/88	5925.03	5926.83	1.80	5861.24	47.30	5879.53
0886	08/18/88	5925.03	5926.83	1.80	5861.24	39.20	5887.63
0886	09/15/88	5925.03	5926.83	1.80	5861.24	56.80	5870.03
0886	10/22/88	5925.03	5926.83	1.80	5861.24	46.90	5879.93
0886	11/15/88	5925.03	5926.83	1.80	5861.24	32.40	5894.43
0886	12/15/88	5925.03	5926.83	1.80	5861.24	30.70	5896.13
0886	01/15/89	5925.03	5926.83	1.80	5861.24	43.90	5882.93
0886	02/17/89	5925.03	5926.83	1.80	5861.24	34.50	5892.33
0886	03/08/89	5925.03	5926.83	1.80	5861.24	28.50	5898.33
0886	04/14/89	5925.03	5926.83	1.80	5861.24	45.70	5881.13
0886	05/05/89	5925.03	5926.83	1.80	5861.24	33.90	5892.93
0886	09/12/89	5925.03	5926.83	1.80	5861.24	17.03	5909.80
0886	11/29/89	5925.03	5926.83	1.80	5861.24	13.00	5913.83
0986	01/05/88	5996.39	5998.23	1.84	5861.04	28.20	5970.03
0986	02/24/88	5996.39	5998.23	1.84	5861.04	37.00	5961.23
0986	03/14/88	5996.39	5998.23	1.84	5861.04	30.60	5967.63
0986	04/11/88	5996.39	5998.23	1.84	5861.04	28.80	5969.43
0986	05/12/88	5996.39	5998.23	1.84	5861.04	28.20	5970.03
0986	06/15/88	5996.39	5998.23	1.84	5861.04	45.10	5953.13
0986	07/15/88	5996.39	5998.23	1.84	5861.04	31.30	5966.93
0986	08/18/88	5996.39	5998.23	1.84	5861.04	29.40	5968.83
0986	09/15/88	5996.39	5998.23	1.84	5861.04	68.90	5929.33
0986	10/22/88	5996.39	5998.23	1.84	5861.04	34.10	5964.13
0986	11/15/88	5996.39	5998.23	1.84	5861.04	29.70	5968.53
0986	12/15/88	5996.39	5998.23	1.84	5861.04	28.60	5969.63
0986	01/15/89	5996.39	5998.23	1.84	5861.04	32.50	5965.73
0986	02/17/89	5996.39	5998.23	1.84	5861.04	29.20	5969.03
0986	03/03/89	5996.39	5998.23	1.84	5861.04	28.40	5969.83
0986	04/14/89	5996.39	5998.23	1.84	5861.04	34.90	5963.33
0986	05/05/89	5996.39	5998.23	1.84	5861.04	30.40	5967.83
0986	06/15/89	5996.39	5998.23	1.84	5861.04	29.00	5969.23

WATER LEVEL SUMMARY

LANDFILL UNWEATHERED SANDSTONE

(All Measurements in Feet)

WELL NUMBER	DATE MEASURED	GROUND ELEVATION	ELEVATION TOP OF CASING	STICK UP	ELEVATION SI/BASE	WATER DEPTH BELOW TOC	WATER ELEVATION
0986	07/07/89	5996.39	5998.23	1.84	5861.04	36.38	5961.85
0986	08/04/89	5996.39	5998.23	1.84	5861.04	30.30	5967.93
0986	09/11/89	5996.39	5998.23	1.84	5861.04	29.39	5968.84
0986	11/29/89	5996.39	5998.23	1.84	5861.04	30.55	5967.68
4187BR	01/06/88	5882.78	5884.55	1.77	5788.99	60.20	5824.35
4187BR	02/04/88	5882.78	5884.55	1.77	5788.99	88.80	5795.75
4187BR	03/14/88	5882.78	5884.55	1.77	5788.99	55.40	5829.15
4187BR	04/11/88	5882.78	5884.55	1.77	5788.99	43.60	5840.95
4187BR	05/12/88	5882.78	5884.55	1.77	5788.99	36.20	5848.35
4187BR	06/15/88	5882.78	5884.55	1.77	5788.99	86.10	5798.45
4187BR	07/15/88	5882.78	5884.55	1.77	5788.99	64.80	5819.75
4187BR	08/18/88	5882.78	5884.55	1.77	5788.99	52.60	5831.95
4187BR	09/15/88	5882.78	5884.55	1.77	5788.99	73.70	5810.85
4187BR	10/22/88	5882.78	5884.55	1.77	5788.99	57.80	5826.75
4187BR	11/15/88	5882.78	5884.55	1.77	5788.99	51.20	5833.35
4187BR	12/15/88	5882.78	5884.55	1.77	5788.99	47.30	5837.25
4187BR	01/15/89	5882.78	5884.55	1.77	5788.99	56.30	5828.25
4187BR	02/17/89	5882.78	5884.55	1.77	5788.99	41.50	5843.05
4187BR	03/08/89	5882.78	5884.55	1.77	5788.99	37.70	5846.85
4187BR	04/14/89	5882.78	5884.55	1.77	5788.99	59.30	5825.25
4187BR	05/05/89	5882.78	5884.55	1.77	5788.99	48.40	5836.15
4187BR	06/18/89	5882.78	5884.55	1.77	5788.99	37.50	5847.05
4187BR	07/07/89	5882.78	5884.55	1.77	5788.99	68.16	5816.39
4187BR	08/04/89	5882.78	5884.55	1.77	5788.99	47.06	5837.49
4187BR	09/11/89	5882.78	5884.55	1.77	5788.99	39.83	5844.72
4187BR	11/08/89	5882.78	5884.55	1.77	5788.99	55.20	5829.35
B207189	09/11/89	5884.80	5886.72	1.92	5809.37	65.41	5821.31
B207189	09/15/89	5884.80	5886.72	1.92	5809.37	74.75	5811.97

UNITED STATES ATOMIC ENERGY COMMISSION

ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO

DESIGN CRITERIA

SANITARY LANDFILL RENOVATIONS

DOW CHEMICAL U.S.A.
ROCKY FLATS DIVISION
BOX 888, GOLDEN, COLORADO

INDEX OF DRAWINGS

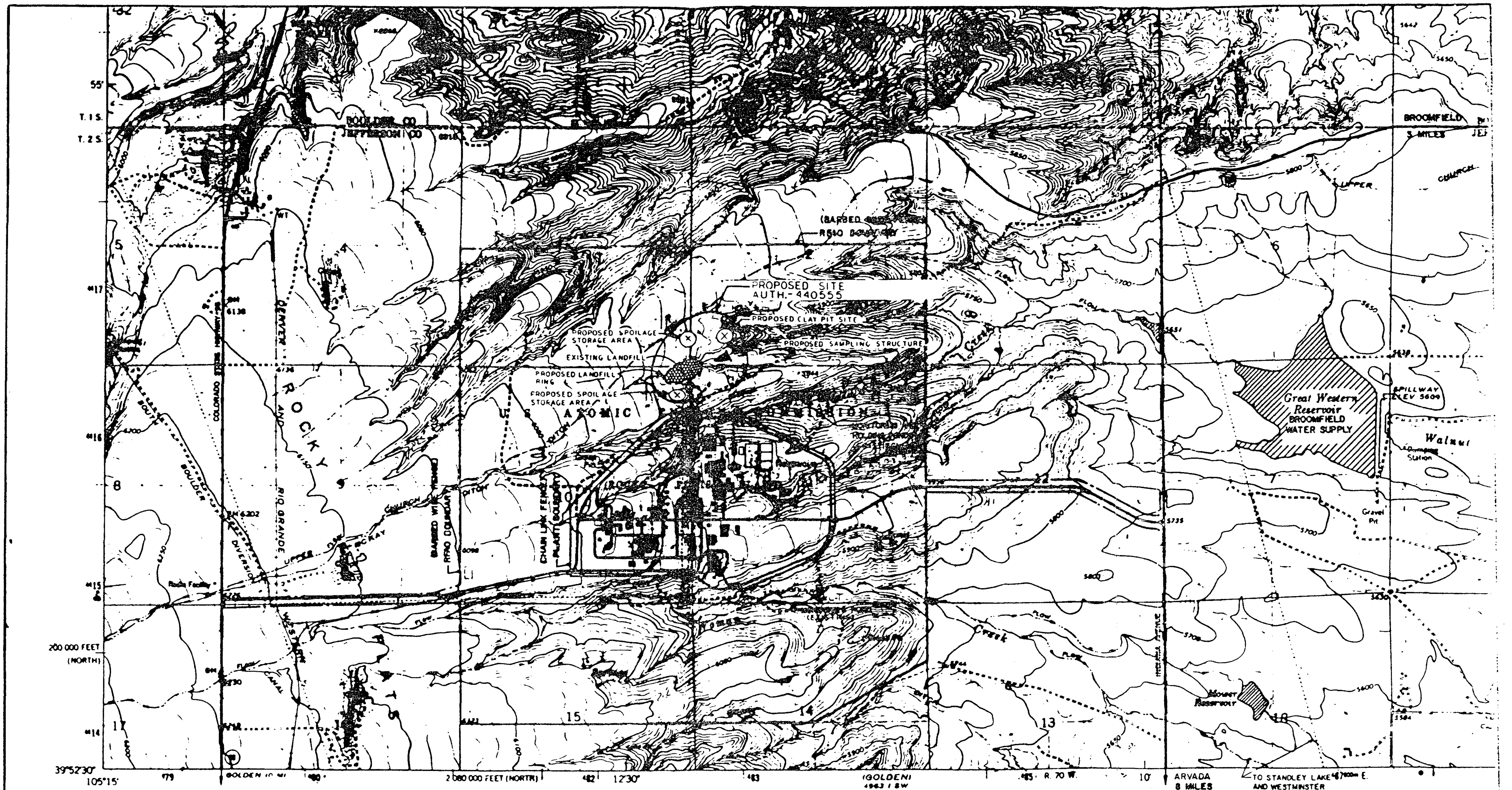
DOW AUTH. - 440555

SHEET NO.	DRAWING TITLE	DWG. NO.	REV.
1	COVER SHEET	D-27296-1	A
2	AREA PLOT	" -2	A
3	SAMPLING STRUCTURE & WATER DIVERSION DETAILS	" -3	A
4	LANDFILL RING & WATER DIVERSION DETAILS	" -4	B

CRITERIA
NOT FOR CONSTRUCTION

A	ORIGINAL ISSUE DESIGN CRITERIA	~	CM	[illegible]	440555
ISSUE	DESCRIPTION	LOC	DATE / BY / APPR'D	CLASSIFIED	REF NO

	BY	DATE	
DESIGNED	RICHTER	4-17-74	U.S. ATOMIC ENERGY COMMISSION, ROCKY FLATS AREA OFFICE, GOLDEN, COLORADO
DRAWN	[illegible]	4-17-74	DOW CHEMICAL U.S.A. A.E.C. CONTRACT AT (29-1)-1106, ROCKY FLATS DIVISION, GOLDEN, COLORADO
CHECKED	~	~	
APPROVED			SANITARY LANDFILL RENOVATIONS COVER SHEET
SUBMITTED	[illegible] 4-30-74		
REVIEWED			
APP'D [illegible]	[illegible]		D 27296-1 A 1 of 4



GRAPHIC SCALE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 MILE

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

1. POLYCONIC PROJECTION-1927 NORTH AMERICAN DATUM 10,000 FT GRIDS BASED ON COLORADO COORDINATE SYSTEM, NORTH AND CENTRAL ZONES. 1000-METER UNIVERSAL TRANSVERSE MERCATOR GRID TICKS ALSO NOTED ON MAP EDGE.
2. TOPOGRAPHY BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS TAKEN 1964 AND FIELD CHECKED 1965
3. THIS MAP IS A PHOTOGRAPHIC ENLARGEMENT OF THE USGA AND USC AND 65 LOUISVILLE, COLORADO QUADRANGLE, 7.5 MINUTE SERIES.

CRITERIA-
NOT FOR CONSTRUCTION

A ORIGINAL ISSUE - DESIGN CRITERIA

U.S. ATOMIC ENERGY COMMISSION

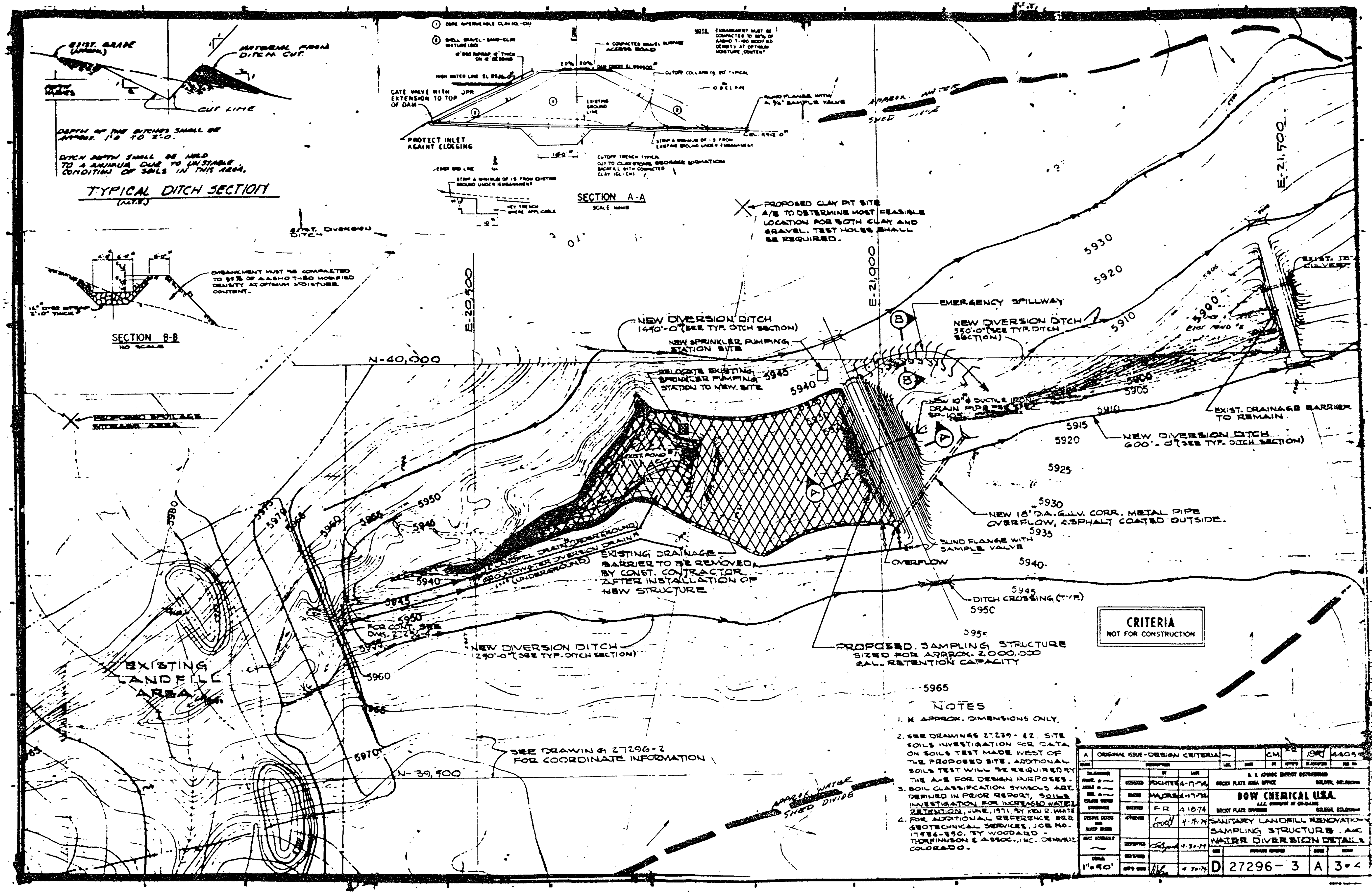
RICHTER 4-17-74
MAJORS 4-17-74

DOW CHEMICAL USA

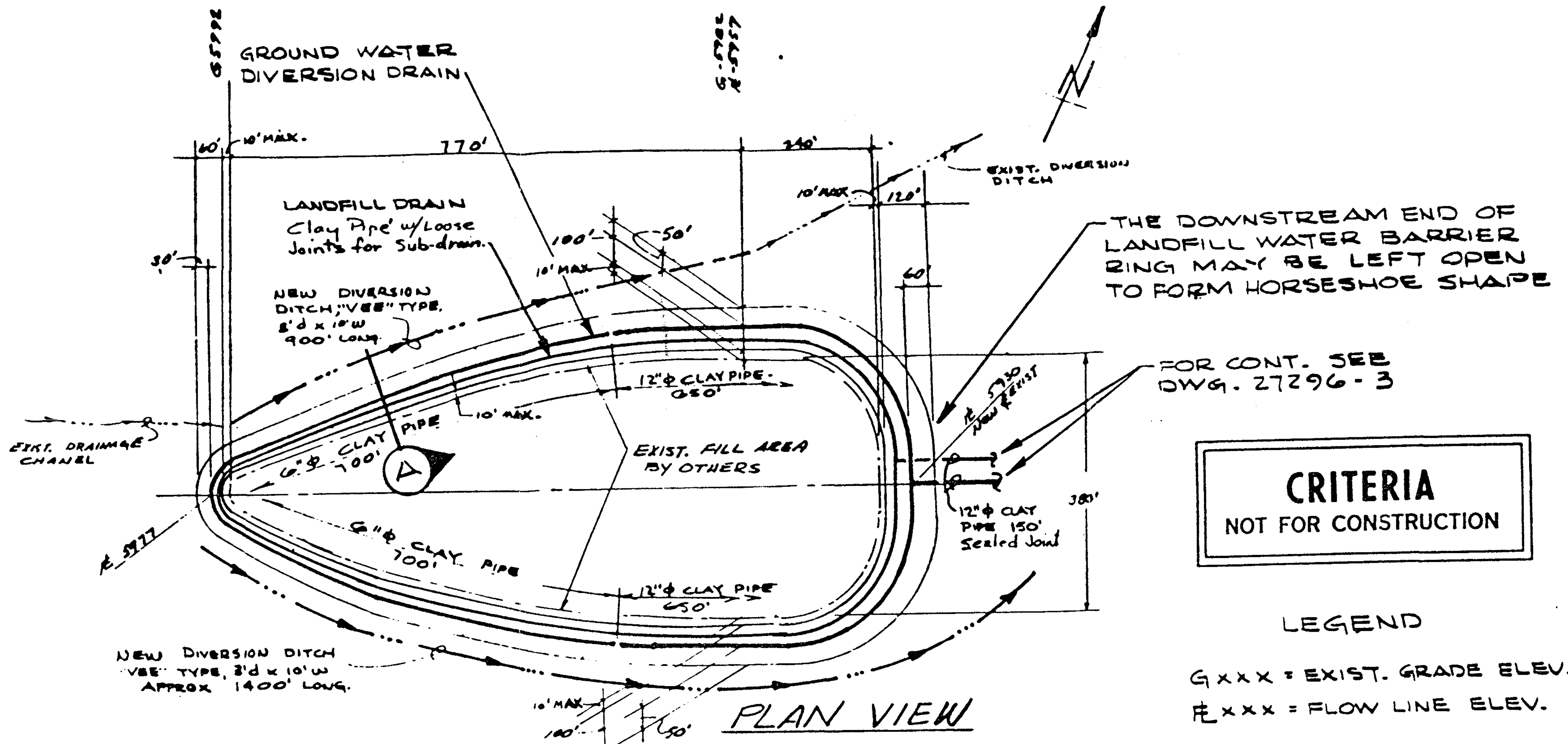
SANITARY LANDFILL
RENOVATIONS
AREA PLOT PLAN

GRAPHIC

D 27296-2 A 2


TYPICAL DITCH SECTION
(N.T.S.)
DEPTH OF THE DITCHES SHALL BE APPROX. 1'0 TO 3'0.
DITCH DEPTH SHALL BE HELD TO A MINIMUM DUE TO UNSTABLE CONDITION OF SOILS IN THIS AREA.
EXIST. GRADE
MATERIAL FROM DITCH CUT.
CUT LINE
SECTION A-A
SCALE: NONE
GATE VALVE WITH JPR EXTENSION TO TOP OF DAM
PROTECT INLET AGAINST CLOGGING
CUTOFF COLLARS
BLIND FLANGE WITH A 3/4" SAMPLE VALVE
EXISTING GROUND LINE
CUTOFF TRENCH TYPICAL
SECTION B-B
NO SCALE
EMBANKMENT MUST BE COMPACTED TO 95% OF AASHO T-180 MODIFIED DENSITY AT OPTIMUM MOISTURE CONTENT.
EXIST. DIVERSION DITCH
PROPOSED CLAY PIT SITE A/E TO DETERMINE MOST FEASIBLE LOCATION FOR BOTH CLAY AND GRAVEL. TEST HOLES SHALL BE REQUIRED.
APPROX. WATER SHED LINE
E-21,500
E-21,000
E-20,500
N-40,000
N-39,900
EMERGENCY SPILLWAY
NEW DIVERSION DITCH 1450'-0"(SEE TYP. DITCH SECTION)
NEW SPRINKLER PUMPING STATION SITE
RELOCATE EXISTING SPRINKLER PUMPING STATION TO NEW SITE
NEW DIVERSION DITCH 550'-0"(SEE TYP. DITCH SECTION)
NEW 10" Ø DUCTILE IRON DRAIN PIPE
EXIST. DRAINAGE BARRIER TO REMAIN.
NEW DIVERSION DITCH 600'-0"(SEE TYP. DITCH SECTION)
EXIST. 18" CULVERT
NEW 18" DIA. G.I.V. CORR. METAL PIPE OVERFLOW, ASPHALT COATED OUTSIDE.
BLIND FLANGE WITH SAMPLE VALVE
OVERFLOW
DITCH CROSSING (TYP.)
EXISTING DRAINAGE BARRIER TO BE REMOVED BY CONST. CONTRACTOR AFTER INSTALLATION OF NEW STRUCTURE
GROUNDWATER DIVERSION DRAIN (UNDERGROUND)
PROPOSED SAMPLING STRUCTURE SIZED FOR APPROX. 2,000,000 GAL. RETENTION CAPACITY
NEW DIVERSION DITCH 1290'-0"(SEE TYP. DITCH SECTION)
FOR CONT. SEE DWG. 27296-4
EXISTING LANDFILL AREA
SEE DRAWING 27296-2 FOR COORDINATE INFORMATION
APPROX. WATER SHED DIVIDE
CRITERIA
NOT FOR CONSTRUCTION
NOTES
1. ✱ APPROX. DIMENSIONS ONLY.
2. SEE DRAWINGS 27239-E2. SITE SOILS INVESTIGATION FOR DATA ON SOILS TEST MADE WEST OF THE PROPOSED SITE. ADDITIONAL SOILS TEST WILL BE REQUIRED BY THE A-E FOR DESIGN PURPOSES.
3. SOIL CLASSIFICATION SYMBOLS ARE DEFINED IN PRIOR REPORT, SOILS INVESTIGATION FOR INCREASED WATER RETENTION, JUNE, 1971 BY KEN R. WHITE
4. FOR ADDITIONAL REFERENCE SEE GEOTECHNICAL SERVICES, JOB NO. 17436-350, BY WOODARD-THORFINNSON & ASSOC., INC. DENVER, COLORADO.
A ORIGINAL ISSUE - DESIGN CRITERIA
U.S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
DOW CHEMICAL U.S.A.
ROCKY FLATS DIVISION
GOLDEN, COLORADO
SANITARY LANDFILL RENOVATION SAMPLING STRUCTURE AND WATER DIVERSION DETAILS
1"=50'
D 27296-3 A 3 of 4

PART	QUAN.	DESCRIPTION	MATERIAL

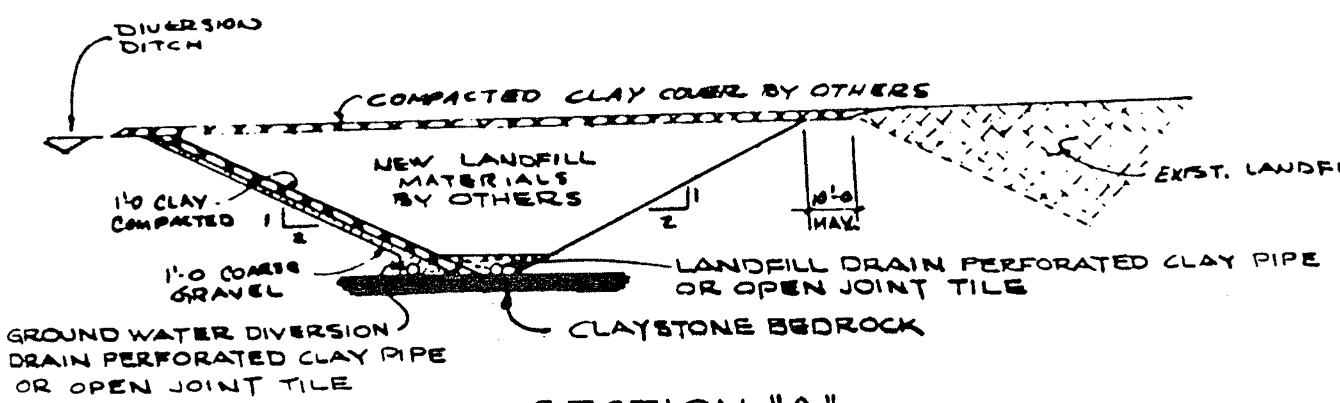


PLAN VIEW

CRITERIA
NOT FOR CONSTRUCTION

LEGEND

Gxxx = EXIST. GRADE ELEV.
℄xxx = FLOW LINE ELEV.



SECTION "A"

ISSUE	DESCRIPTION	LOC.	DATE	BY	APPR'D	CLASSIFIER	JOB NO.
B	ISSUED FOR DESIGN CRITERIA	~	4-30-74	CM	F.R.	[illegible]	440555
A	ORIGINAL ISSUE-DESIGN CRITERIA	~	4-19-74	CM	F.R.	[illegible]	440555

TOLERANCES		BY	DATE
FRACT. ± ~ ANGLE ± ~ DEC. ± ~ UNLESS NOTED OTHERWISE		RICHTER	4-17-74
	DRAWN	MAJORS	4-17-74
	CHECKED	F.R.	4.17.74
REMOVE BURRS AND SHARP EDGES	APPROVED	Fowell	4-17-74
NEXT ASSEMBLY ~	SUBMITTED	F. Bryant	4 30 74
	REC'M'DED		
SCALE: NO SCALE	APP'D (AEC)	[illegible]	4-30-74

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

DOW CHEMICAL U.S.A.
A.E.C. CONTRACT AT (29-1)-1106
ROCKY FLATS DIVISION GOLDEN, COLORADO

SANITARY LANDFILL RENOVATIONS
LANDFILL RING & WATER
DIVERSION DETAILS

SIZE	DRAWING NUMBER	ISSUE	SHEET
B	27296 - 4	B	4 of 4

GPO 780-826/1

UNITED STATES ATOMIC ENERGY COMMISSION

ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS OFFICE
GOLDEN, COLORADO

SANITARY LANDFILL RENOVATIONS
ROCKY FLATS

ZEFF, COGORNO & SEALY INC., DENVER, COLORADO
TRI-CONSULTANTS INC., DENVER, COLORADO
HYDRO-TRIAD LTD., DENVER, COLORADO

I hereby certify that these plans for the SANITARY LANDFILL RENOVATIONS, ROCKY FLATS, were prepared under my direct supervision for the owners thereof.

Registered Professional Engineer Colorado 5235

RONALD E. HALL JR. REGISTERED PROFESSIONAL ENGINEER 5235 STATE OF COLORADO

I hereby certify that on behalf of the UNITED STATES ATOMIC ENERGY COMMISSION, OWNER, whose Post Office address is:
Rocky Flats Area Office
P. O. Box 928
Golden, Colorado 80401
Do hereby approve & accept these plans for the SANITARY LANDFILL RENOVATIONS, ROCKY FLATS.

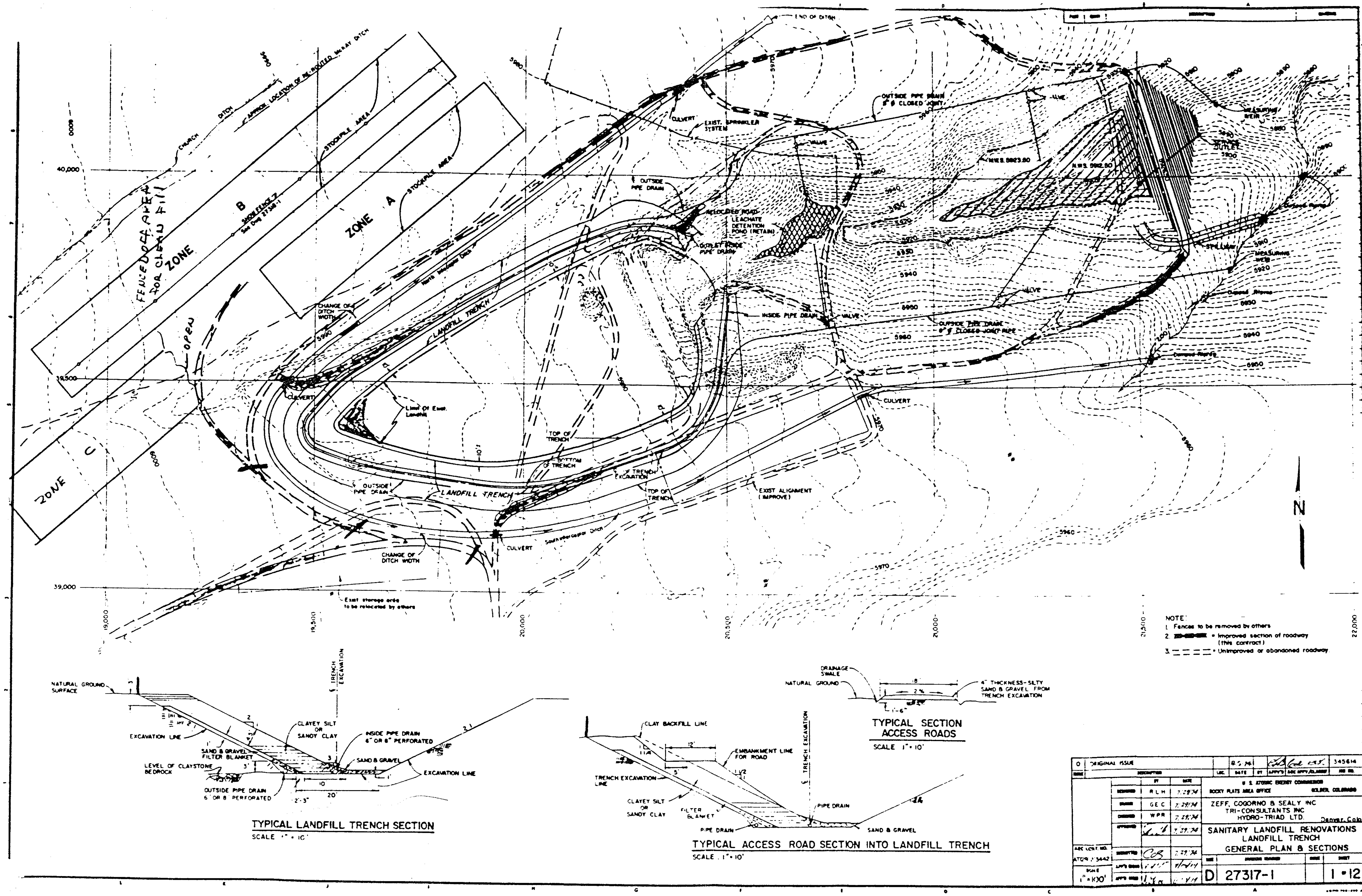
Assistant Manager For Construction

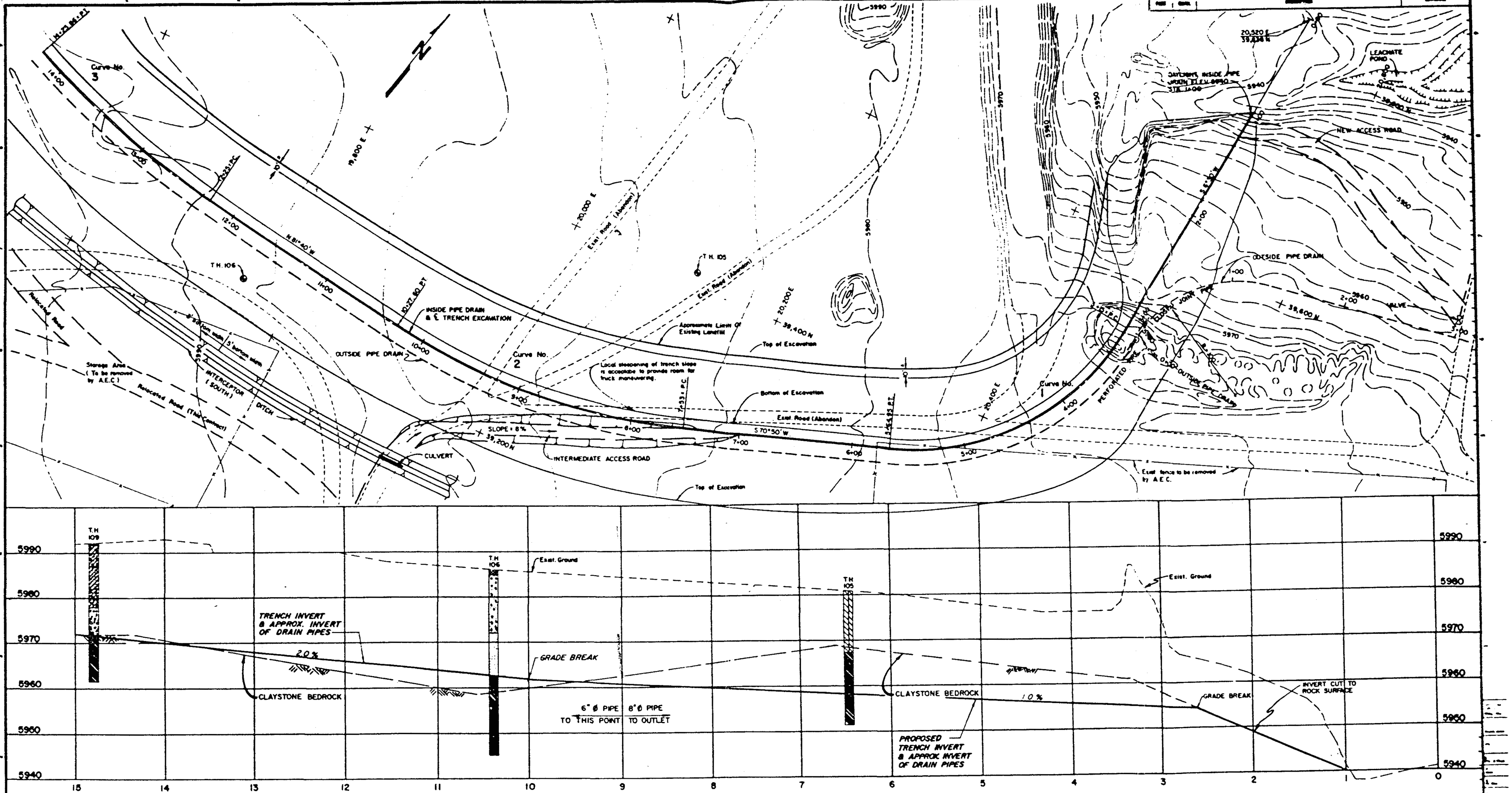
Approved on the 22 day of July, 1974.

INVITATION NO
292-75-3

INDEX OF SHEETS

0	ORIGINAL ISSUE		8-5-78		345614
DESIGNED	R L H	7.24.74	U. S. ATOMIC ENERGY COMMISSION ROCKY FLATS AREA OFFICE GOLDEN, COLORADO		
DRAWN	G E C	7.23.74	ZEFF, COGORNO & SEALY INC. TRI-CONSULTANTS INC. HYDRO-TRIAD LTD. Denver, Colo		
CHECKED	W P R				
APPROVED			SANITARY LANDFILL RENOVATIONS FACILITY NO. 219 TITLE SHEET		
AEC CONT. NO. AT(23-2)-3442					
SCALE NONE			D	27317-0	


ZONE A
ZONE B
ZONE C
FENCED OFF AREA FOR CLEAN FILL
STOCKPILE AREA
APPROX. LOCATION OF RE-ROUTED McKAY DITCH
CHURCH DITCH
SNOW FENCE
OPEN
END OF DITCH
CULVERT
EXIST. SPRINKLER SYSTEM
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT
VALVE
OUTSIDE PIPE DRAIN
RELOCATED ROAD
LEACHATE DETENTION POND (RETAIN)
OUTLET INSIDE PIPE DRAIN
INSIDE PIPE DRAIN
OUTSIDE PIPE DRAIN 8" Ø CLOSED JOINT PIPE
MEASURING WEIR
SPILLWAY
OUTLET
CHANGE OF DITCH WIDTH
LANDFILL TRENCH
Limit Of Exist. Landfill
TOP OF TRENCH
BOTTOM OF TRENCH
℄ TRENCH EXCAVATION
EXIST ALIGNMENT (IMPROVE)
South Interceptor Ditch
North Interceptor Ditch
Exist. storage area to be relocated by others
N
NOTE:
1. Fences to be removed by others
2. = Improved section of roadway (this contract)
3. = Unimproved or abandoned roadway
TYPICAL LANDFILL TRENCH SECTION
SCALE 1" = 10'
NATURAL GROUND SURFACE
EXCAVATION LINE
CLAYEY SILT OR SANDY CLAY
INSIDE PIPE DRAIN 6" OR 8" PERFORATED
SAND & GRAVEL
SAND & GRAVEL FILTER BLANKET
LEVEL OF CLAYSTONE BEDROCK
OUTSIDE PIPE DRAIN 6" OR 8" PERFORATED
TYPICAL ACCESS ROAD SECTION INTO LANDFILL TRENCH
SCALE 1" = 10'
CLAY BACKFILL LINE
EMBANKMENT LINE FOR ROAD
TRENCH EXCAVATION LINE
FILTER BLANKET
PIPE DRAIN
TYPICAL SECTION ACCESS ROADS
SCALE 1" = 10'
DRAINAGE SWALE
NATURAL GROUND
4" THICKNESS-SILTY SAND & GRAVEL FROM TRENCH EXCAVATION
0 ORIGINAL ISSUE
U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO
R L H 7.29.74
G E C 7.29.74
W P R 7.29.74
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
GENERAL PLAN & SECTIONS
SCALE 1" = 100'
D 27317-1
1 = 12
345614



℄ CURVE DATA

1.
$\Delta = 64°20'$
R = 222.6'
T = 140'
P.C = 3+15.00
P.T = 5+64.95

2.
$\Delta = 27°30'$
R = 572.13'
T = 140'
P.C. = 7+53.00
P.T. = 10+27.60

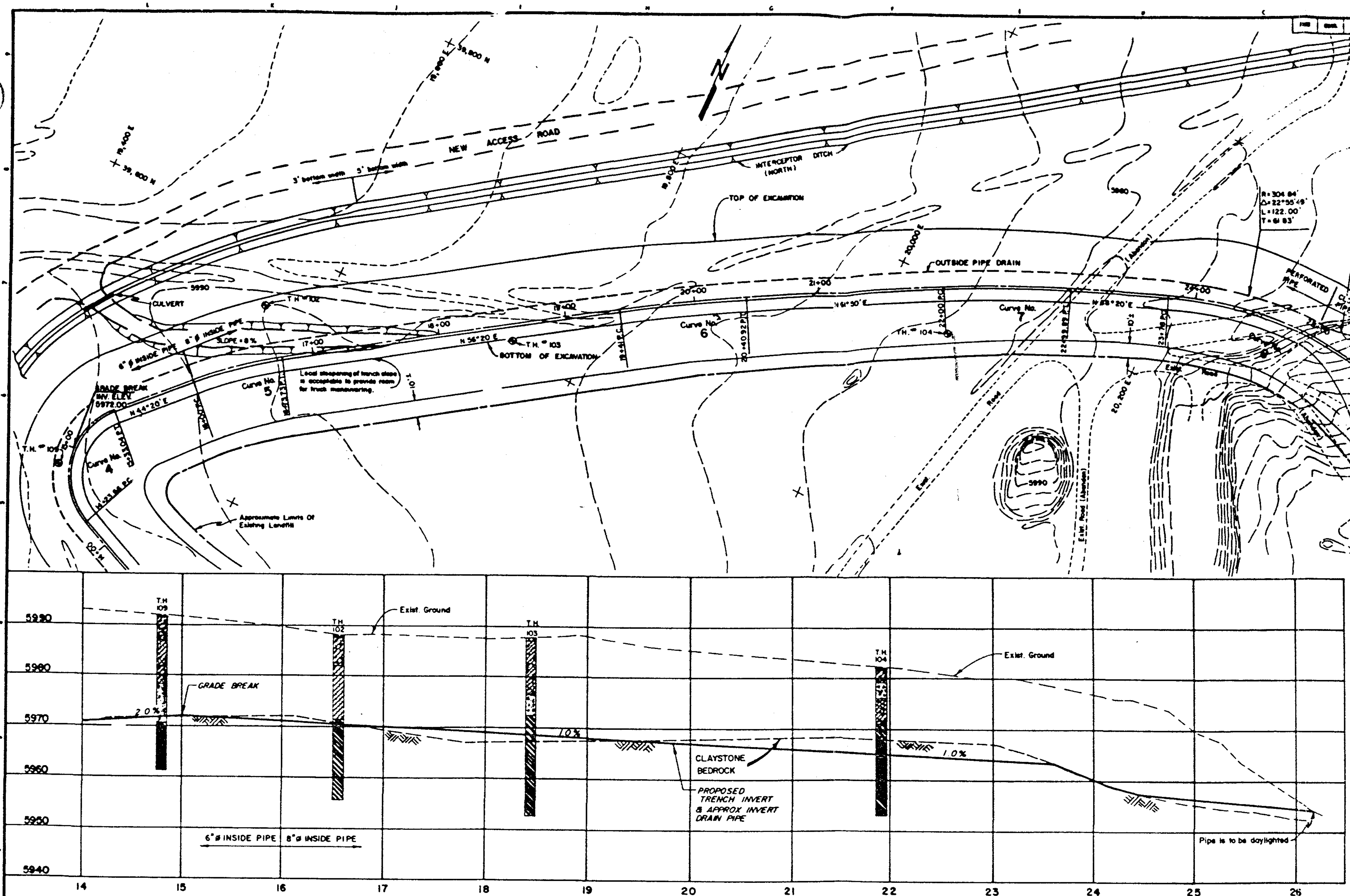
3.
$\Delta = 15°00'$
R = 759.58'
T = 100'
P.C. = 12+25.00
P.T. = 14+23.86

SCALES:
PLAN - 1" = 40'
PROFILE - 1" = 50' HORIZ.
1" = 10' VERT.

NOTES:
1. PROFILE SHOWS INVERT OF TRENCH & INSIDE PIPE DRAIN ONLY. OUTSIDE PIPE DRAIN NOT SHOWN.
2. SECTION OF COMPLETED TRENCH WITH CLAY BARRIER SHOWN ON DWG 27317-1
3. NORTH SIDE OF TRENCH SHOWN ON DWG 27317-3
4. OUTSIDE PIPE DRAIN PROFILE SHOWN ON DWG 27317-4
5. INTERCEPTOR DITCH PROFILE SHOWN ON DWG 27317-5 & 27317-6

0	ORIGINAL ISSUE		8-5-74			345614

	BY	DATE	
	RLH	7-29-74	U. S. ATOMIC ENERGY COMMISSION — ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO
	GEC	7-29-74	ZEFF, COGORNO & SEALY INC. TRI-CONSULTANTS INC. HYDRO-TRIAD. LTD. Denver, Colo
	WPR	7/29/74	
		7/29/74	SANITARY LANDFILL RENOVATIONS LANDFILL TRENCH PLAN & PROFILE 0 TO 15+00
AEC CONT. NO. AT(29-2)1344	COS	7-29-74	
SCALE AS SHOWN		7/29/74	D 27317-2 2 = 12



℄ CURVE DATA

4.	5.	6.	7.	8.
Δ = 111°00'	Δ = 12°00'	Δ = 5°30'	Δ = 6°30'	Δ = 37°42'30"
R = 56.36'	R = 352.03'	R = 1040.94'	R = 880.53'	R = 292.84'
T = 82.00'	T = 37.00	T = 50.00'	T = 50.00'	T = 100.00'
P.C = 14+23.86	P.C = 16+00.00	P.C = 19+41	P.C = 22+00	P.C = 23+78
P.T = 15+33.04	P.T = 16+73.73	P.T = 20+40.92	P.T = 22+99.89	P.T = 25+70.73

SCALES:
PLAN - 1" = 40'
PROFILE - 1" = 50' HORIZ.
1" = 10' VERT.

NOTES:
1. PROFILE SHOWS ONLY INVERT OF TRENCH AND INSIDE PIPE DRAIN ONLY, OUTSIDE PIPE DRAIN NOT SHOWN.
2. SECTION OF COMPLETED TRENCH WITH CLAY BARRIER SHOWN ON DWG 27317-1
3. SOUTH SIDE OF TRENCH SHOWN ON DWG. 27317-2
4. OUTSIDE PIPE DRAIN PROFILE SHOWN ON DWG 27317-4
5. INTERCEPTOR DITCH PROFILE SHOWN ON DWG. 27317-5 & 27317-6

0	ORIGINAL ISSUE	8-5-74	345614

R L H 7/29/74
G.E.C 7/29/74
W.P.R 7/29/74
7/29/74

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

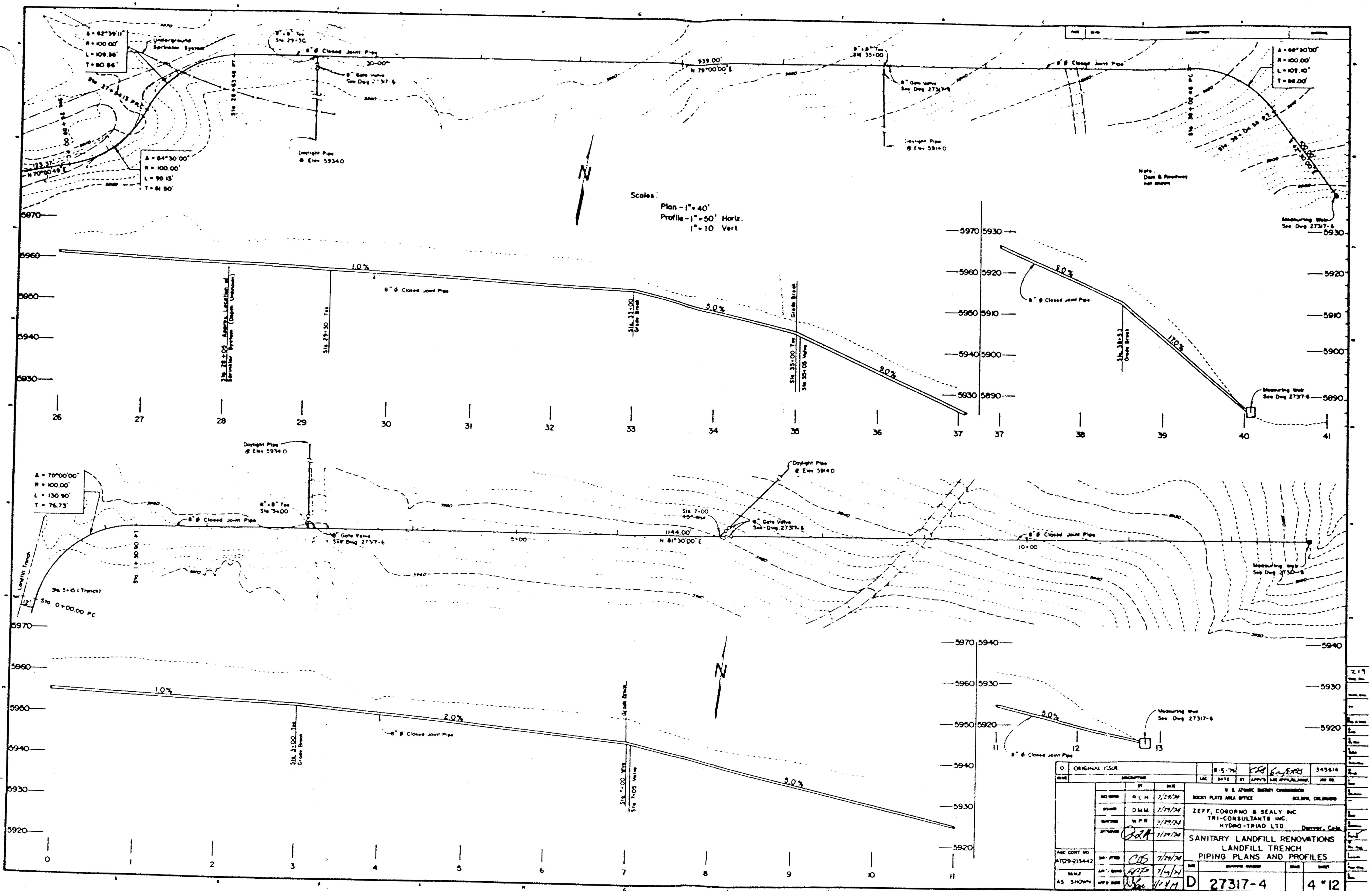
ZEFF, COGORNO & SEALY INC.
TRI-CONSULTANTS INC.
HYDRO-TRIAD LTD Denver, Colo.

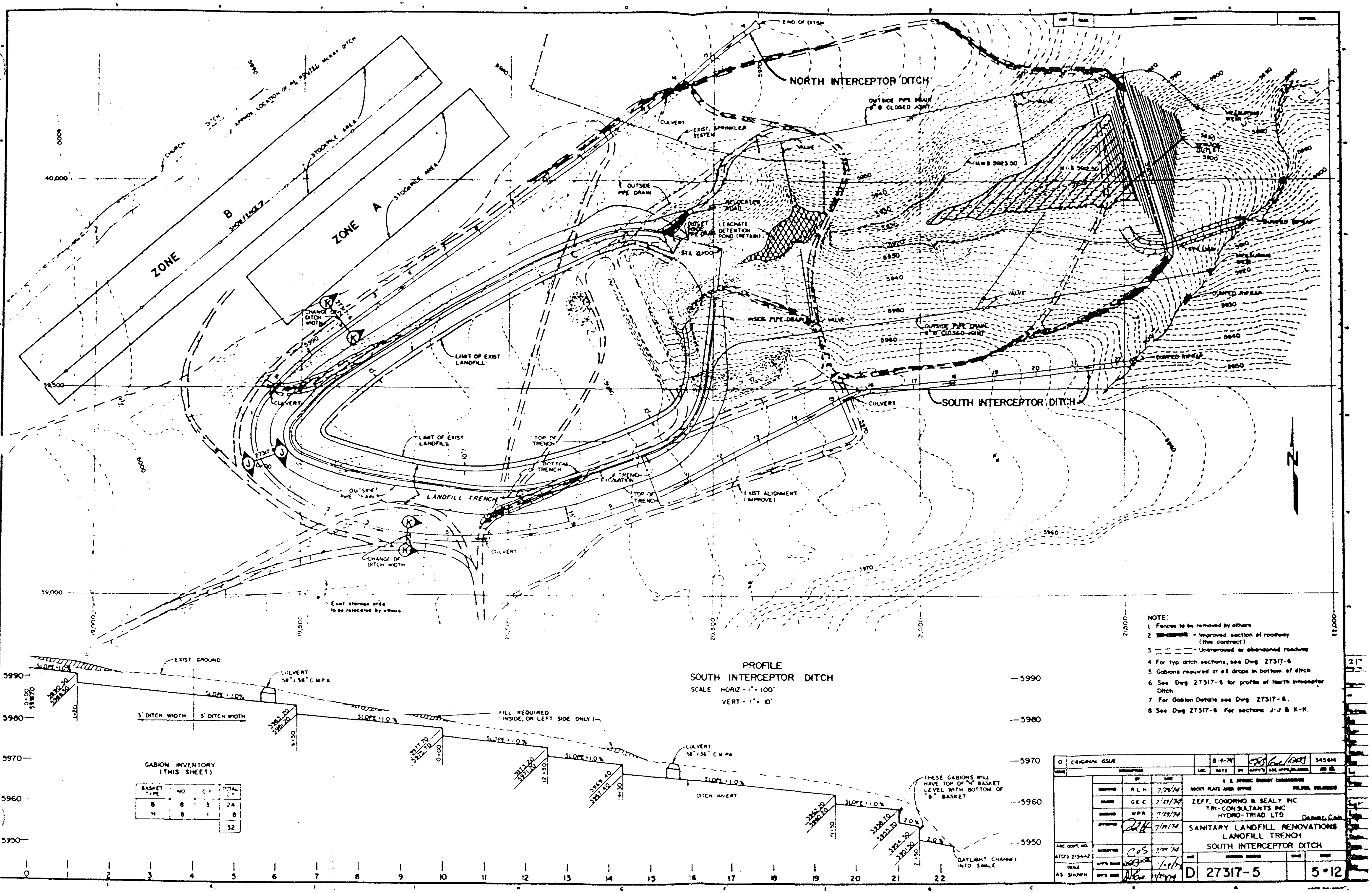
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
PLAN PROFILE 15+00 TO 25+75

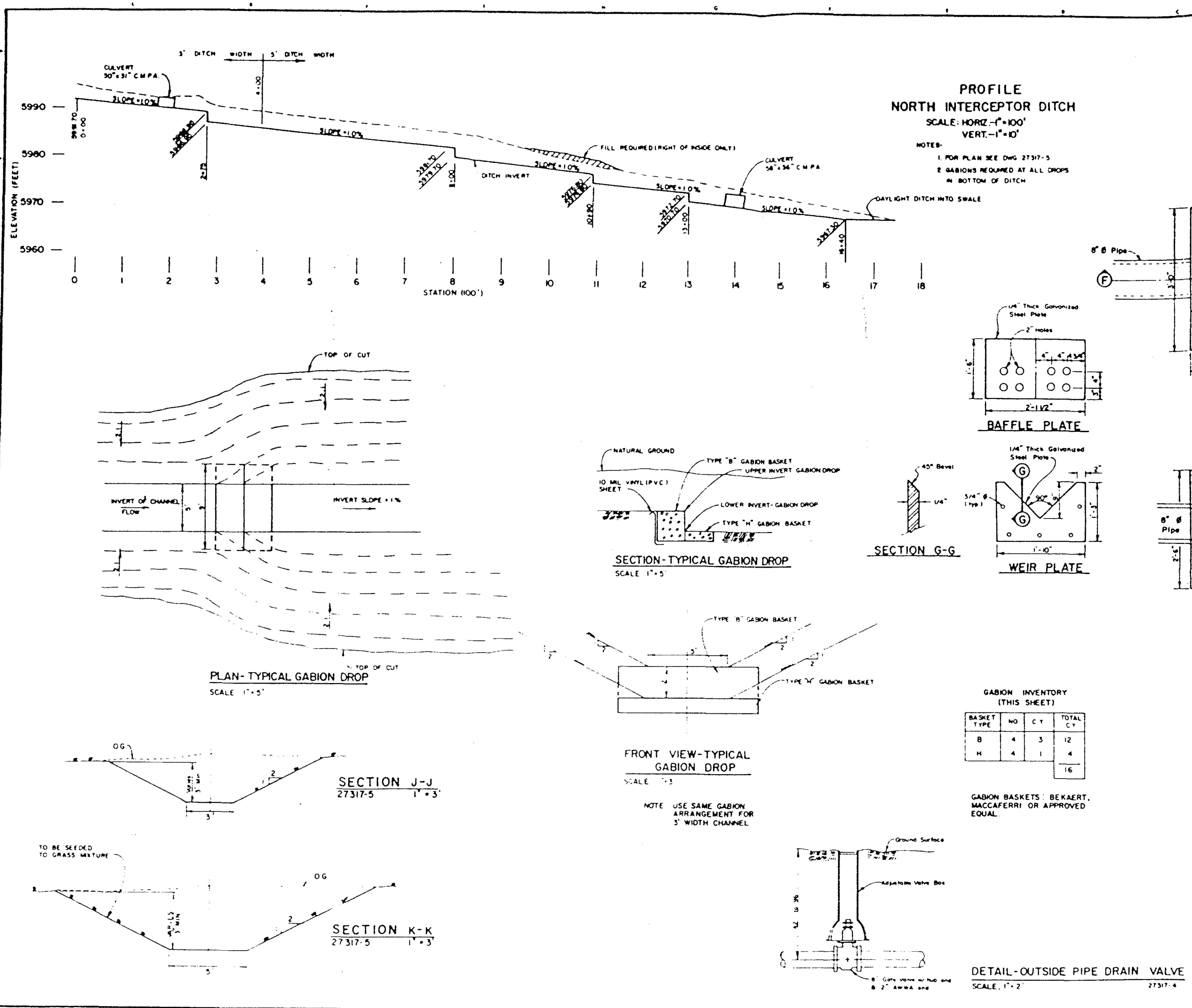
AEC CONT. NO. AT(29-1)-3446
SCALE AS SHOWN
CWB 7/29/74

D 27317-3 3 of 12

219


Scales:
Plan - 1" = 40'
Profile - 1" = 50' Horiz.
1" = 10 Vert.
8" Ø Closed Joint Pipe
Daylight Pipe @ Elev 5934.0
Daylight Pipe @ Elev 5914.0
Measuring Weir See Dwg 27317-6
Note: Dam & Roadway not shown
1.0%
5.0%
9.0%
17.0%
2.0%
N 79°00'00" E
N 81°30'00" E
U.S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
ZEFF, COGORNO & SEALY INC.
TRI-CONSULTANTS INC.
HYDRO-TRIAD LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
PIPING PLANS AND PROFILES
AEC CONT NO AT(29-2)-3442
SCALE AS SHOWN
0 ORIGINAL ISSUE 8-5-74
D 27317-4
4 of 12


NORTH INTERCEPTOR DITCH
END OF DITCH
SOUTH INTERCEPTOR DITCH
OUTSIDE PIPE DRAIN 8" CLOSED JOINT
INSIDE PIPE DRAIN
VALVE
CULVERT
EXIST. SPRINKLER SYSTEM
OUTSIDE PIPE DRAIN
RELOCATED ROAD
LEACHATE DETENTION POND (RETAIN)
STA 0+00
DUMPED RIP RAP
ZONE A
ZONE B
STOCKPILE AREA
APPROX. LOCATION OF MC KENZIE MCKAY DITCH
CHANGE OF DITCH WIDTH
LIMIT OF EXIST LANDFILL
TOP OF TRENCH
BOTTOM TRENCH
TRENCH EXCAVATION
LANDFILL TRENCH
OUTSIDE PIPE DRAIN
EXIST ALIGNMENT (IMPROVE)
Exist storage area to be relocated by others
39,000
39,500
40,000
PROFILE
SOUTH INTERCEPTOR DITCH
SCALE HORIZ - 1" = 100'
VERT - 1" = 10'
EXIST GROUND
CULVERT 58" x 36" C M P A
3' DITCH WIDTH
5' DITCH WIDTH
FILL REQUIRED INSIDE, OR LEFT SIDE ONLY
SLOPE = 1.0%
DITCH INVERT
THESE GABIONS WILL HAVE TOP OF "H" BASKET LEVEL WITH BOTTOM OF "B" BASKET
DAYLIGHT CHANNEL INTO SWALE
GABION INVENTORY (THIS SHEET)
BASKET TYPE | NO | C Y | TOTAL C Y
B | 8 | 3 | 24
H | 8 | 1 | 8
 | | | 32
NOTE:
1 Fences to be removed by others
2 = Improved section of roadway (this contract)
3 = Unimproved or abandoned roadway.
4 For typ ditch sections, see Dwg. 27317-6
5 Gabions required at all drops in bottom of ditch.
6. See Dwg 27317-6 for profile of North Interceptor Ditch.
7 For Gabion Details see Dwg. 27317-6.
8 See Dwg. 27317-6 For sections J-J & K-K.
0 ORIGINAL ISSUE 8-4-74 345814
RLH 7/29/74
GEC 7/29/74
WPR 7/29/74
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD.
Denver, Colo
SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
SOUTH INTERCEPTOR DITCH
AT(29-2)-3442
AS SHOWN
D 27317-5
5 • 12



GABION INVENTORY
(THIS SHEET)

BASKET TYPE	NO	C.Y.	TOTAL C.Y.
B	4	3	12
H	4	1	4
			16

GABION BASKETS: BEKAERT, MACCAFERRI OR APPROVED EQUAL.

0	ORIGINAL ISSUE	8-5-74	345614

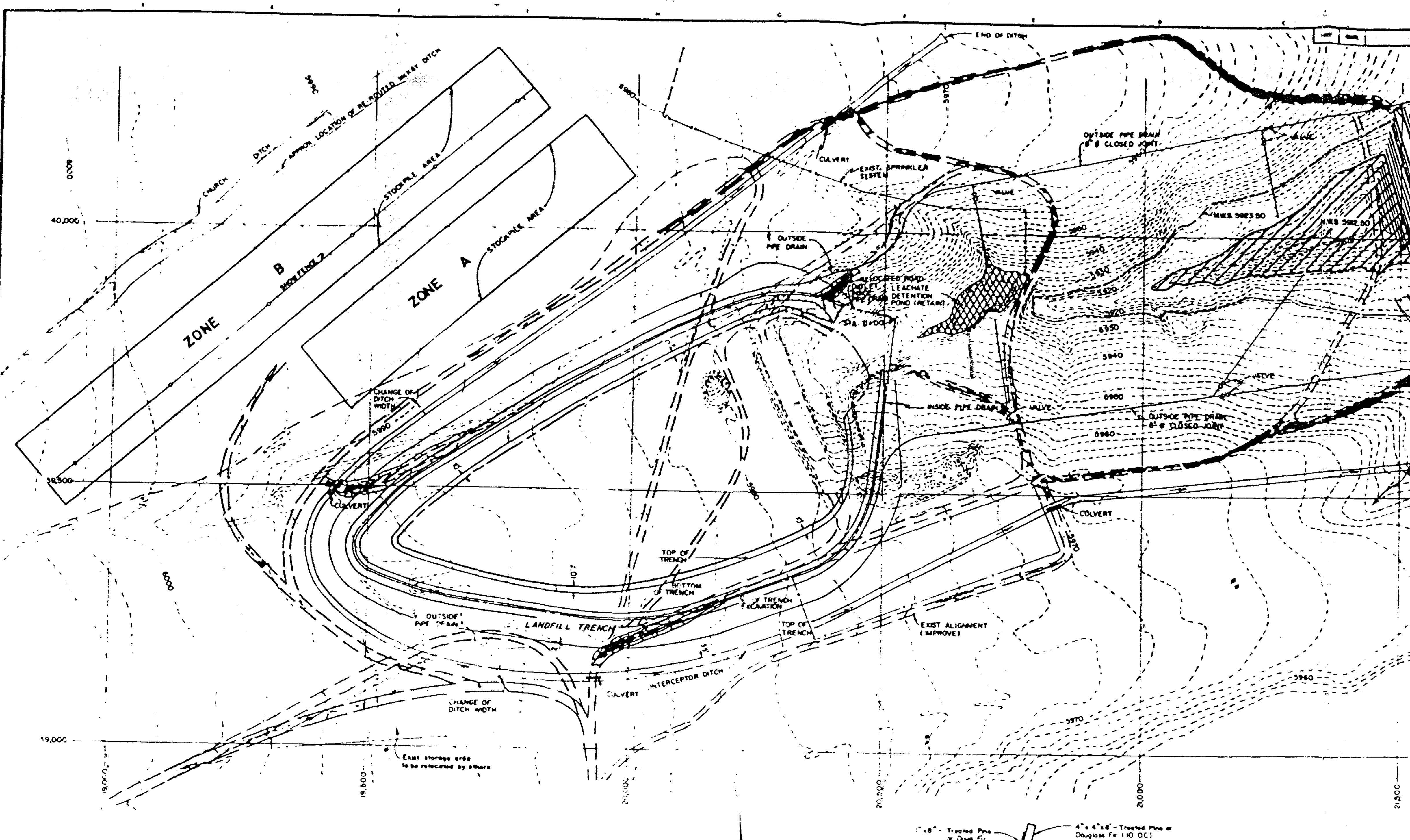
U.S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

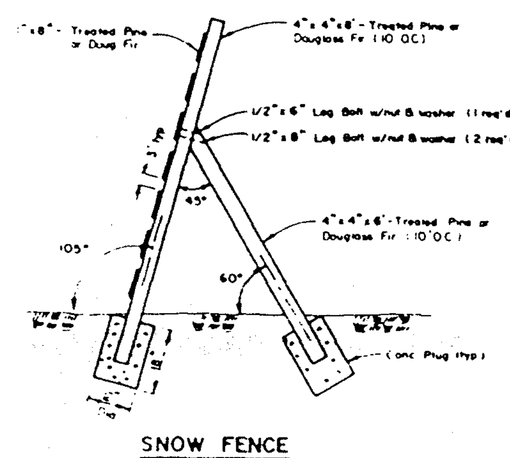
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD
Denver, Colo.

SANITARY LANDFILL RENOVATIONS
LANDFILL TRENCH
NORTH INTERCEPTOR DITCH

AEC CONT. NO. AT(29-2)3442
SCALE AS SHOWN

D 27317-6 6 of 12





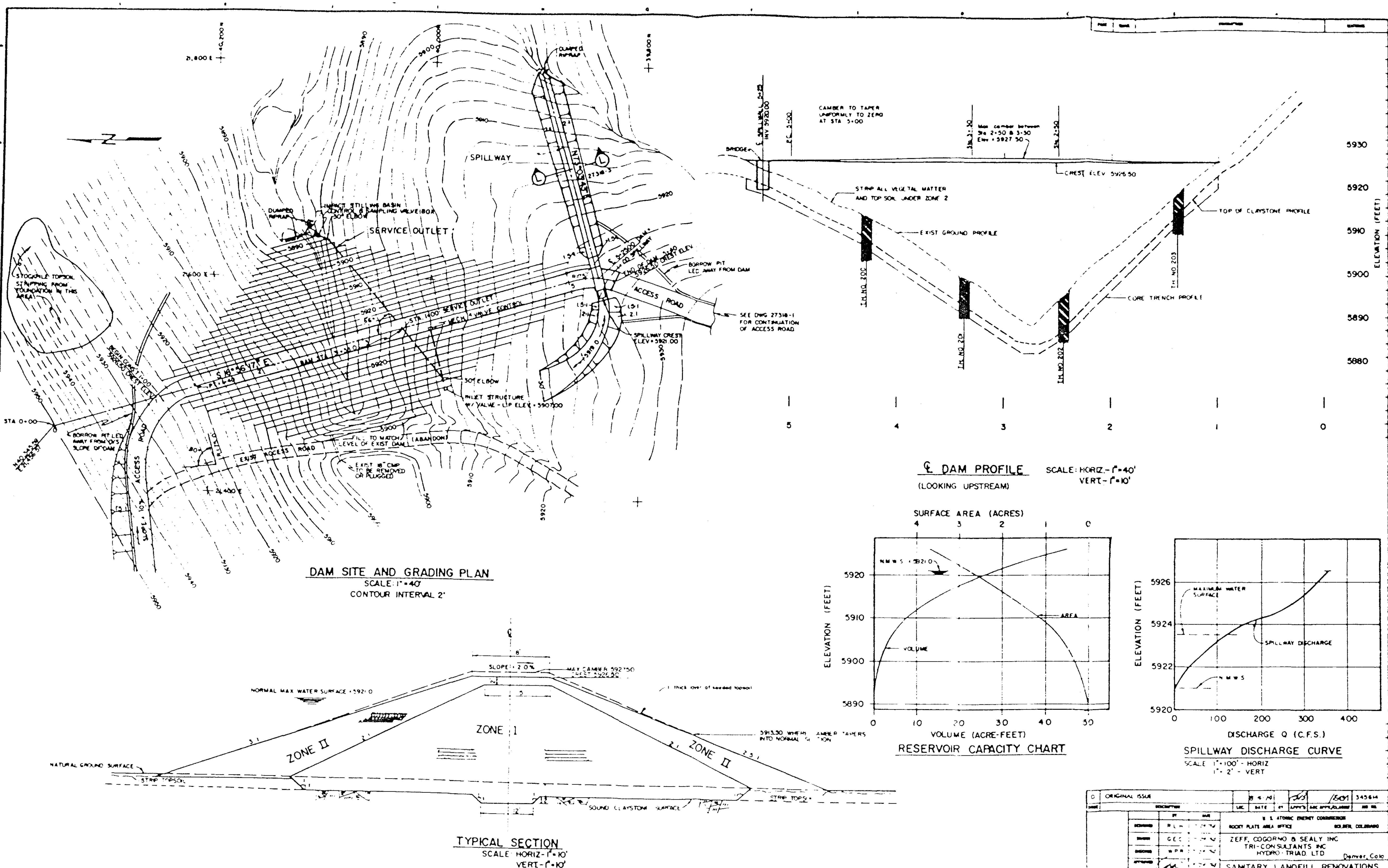
SNOW FENCE
SCALE 1" = 2'

NOTE:
1. Fences to be removed by others
2. = Improved section of roadway (this contract)
3. = Unimproved or abandoned roadway

Note:
Post may be metal if approved by contracting officer

0	ORIGINAL ISSUE			345614
	U. S. ATOMIC ENERGY COMMISSION	ROCKY FLATS AREA OFFICE	GOLDEN, COLORADO	
R L H	7/29/74	ZEFF, COGORNO & SEALY INC		
G E C	7/29/74	TRI-CONSULTANTS INC		
W P R	7/29/74	HYDRO-TRIAD LTD	Denver, Colo	
		SANITARY LANDFILL RENOVATIONS		
		SAMPLING STRUCTURE		
AT(29-2)3442		GENERAL PLAN-DAM & RESERVOIR		
1" = 100'		D	27318-1	7 of 12

219



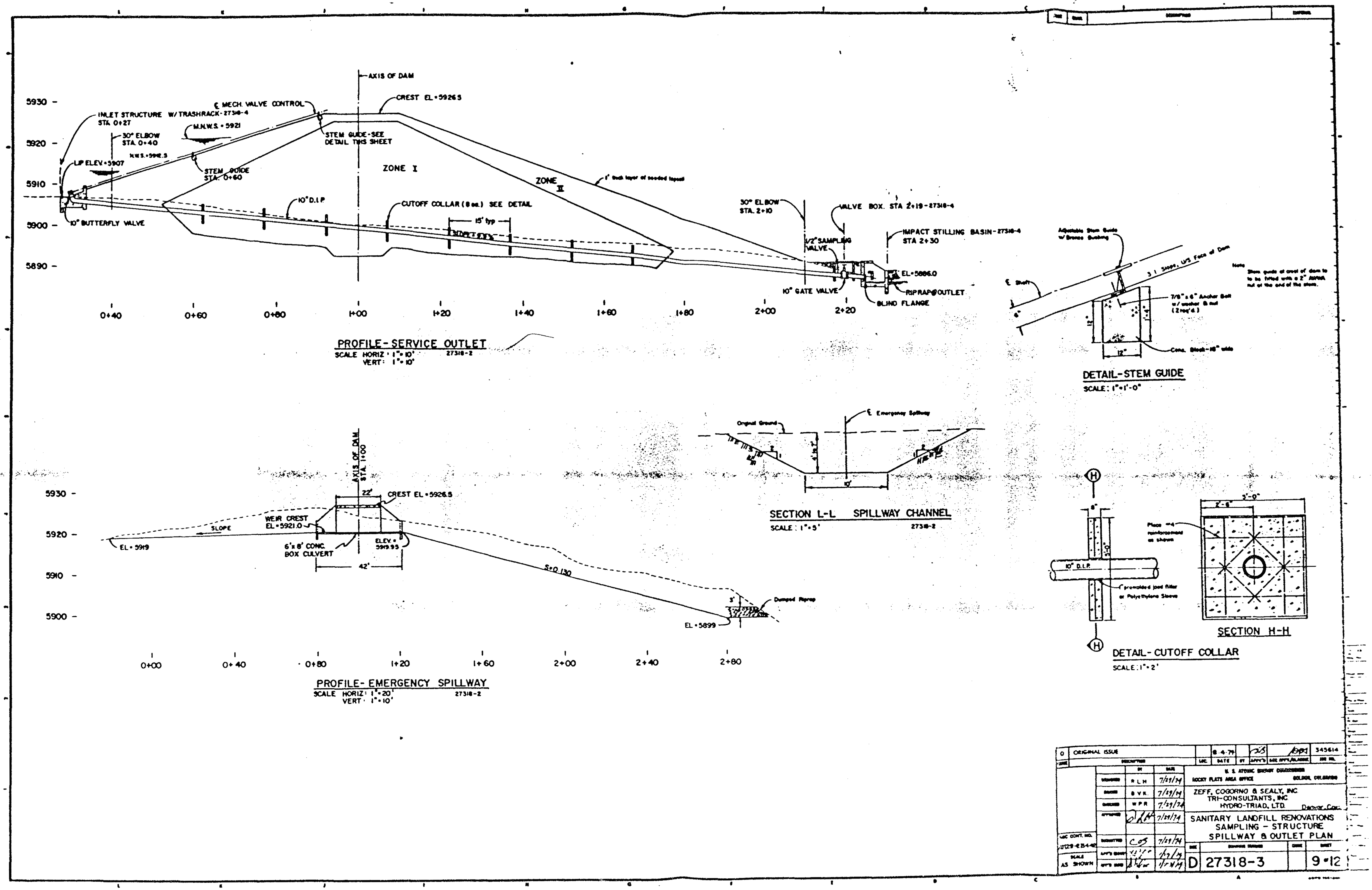
0	ORIGINAL ISSUE	8-4-81			345614

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

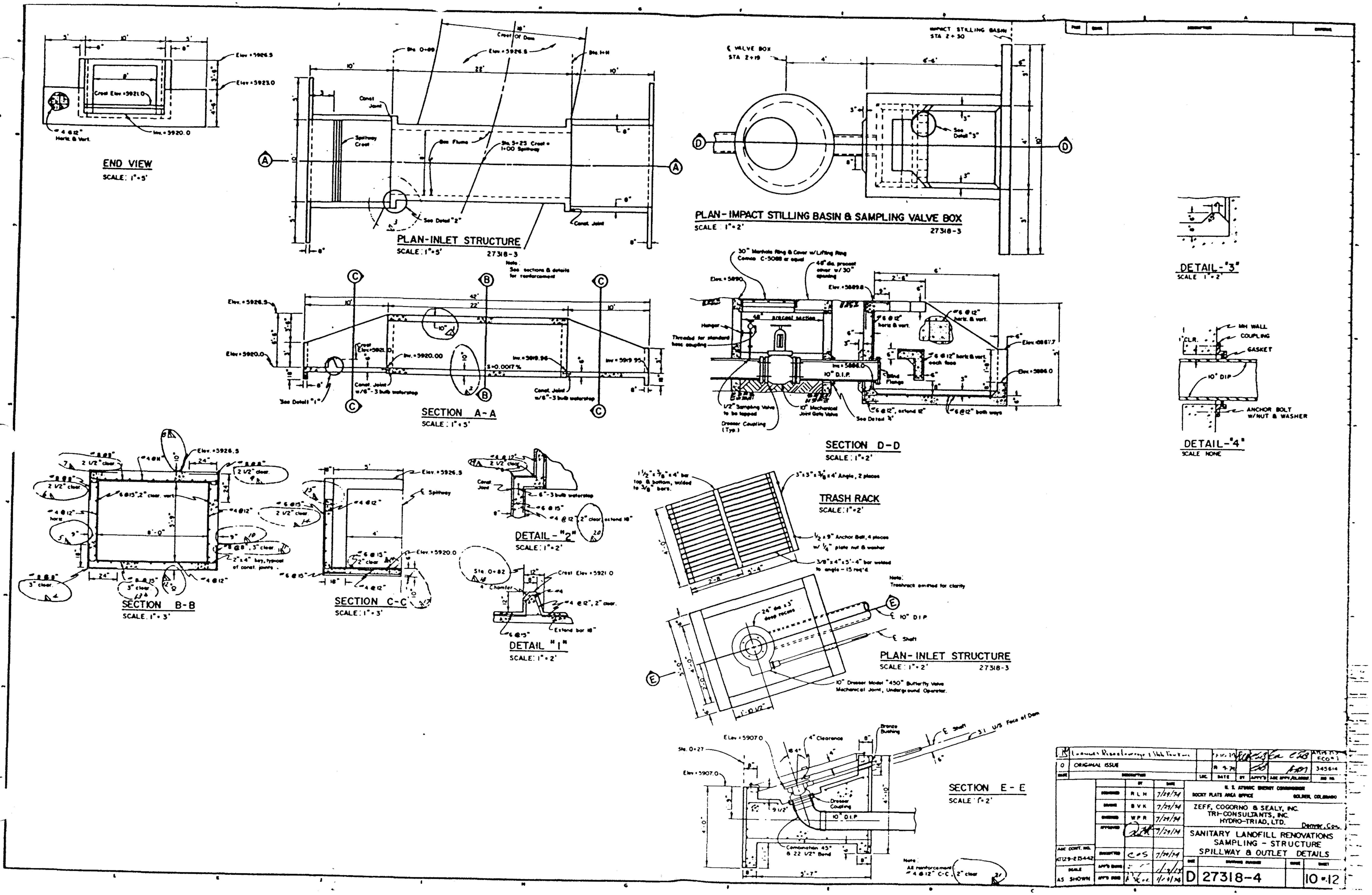
ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD
Denver, Colo

SANITARY LANDFILL RENOVATIONS
SAMPLING STRUCTURE
PLAN, PROFILE & SECTIONS - DAM

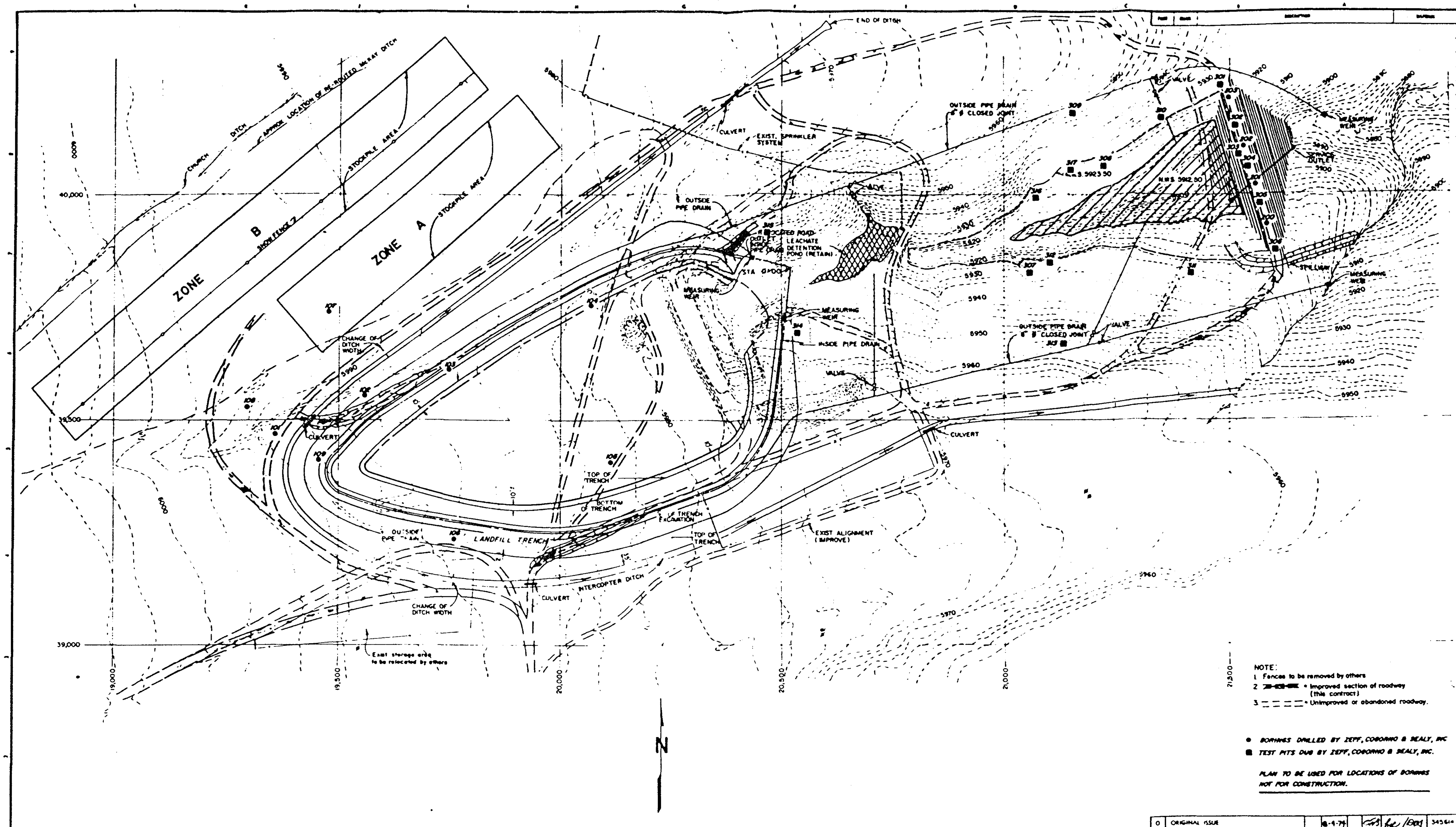
AS SHOWN — D 27318-2 — 8 - 12



AXIS OF DAM
CREST EL • 5926.5
℄ MECH. VALVE CONTROL
INLET STRUCTURE W/TRASHRACK - 27318-4 STA. 0+27
30° ELBOW STA. 0+40
M.N.W.S. • 5921
N.W.S. • 5912.5
LIP ELEV • 5907
STEM GUIDE-SEE DETAIL THIS SHEET
STEM GUIDE STA. 0+60
ZONE I
ZONE II
10" D.I.P.
CUTOFF COLLAR (8 ea.) SEE DETAIL
15' typ
10" BUTTERFLY VALVE
30° ELBOW STA. 2+10
VALVE BOX STA. 2+19 - 27318-4
1/2" SAMPLING VALVE
IMPACT STILLING BASIN - 27318-4 STA 2+30
EL • 5886.0
10" GATE VALVE
RIPRAP @ OUTLET
BLIND FLANGE
5930
5920
5910
5900
5890
0+40
0+60
0+80
1+00
1+20
1+40
1+60
1+80
2+00
2+20
PROFILE - SERVICE OUTLET
SCALE HORIZ : 1" = 10'
VERT : 1" = 10'
27318-2
DETAIL - STEM GUIDE
SCALE : 1" = 1'-0"
AXIS OF DAM STA. 1+00
CREST EL • 5926.5
22'
WEIR CREST EL • 5921.0
SLOPE
EL • 5919
6' x 8' CONC. BOX CULVERT
ELEV • 5919.95
42'
S = 0.130
Dumped Riprap
EL • 5899
3'
0+00
0+40
0+80
1+20
1+60
2+00
2+40
2+80
PROFILE - EMERGENCY SPILLWAY
SCALE HORIZ : 1" = 20'
VERT : 1" = 10'
27318-2
Original Ground
℄ Emergency Spillway
10'
SECTION L-L SPILLWAY CHANNEL
SCALE : 1" = 5'
27318-2
10" D.I.P.
3'-0"
2'-6"
SECTION H-H
DETAIL - CUTOFF COLLAR
SCALE : 1" = 2'
0 ORIGINAL ISSUE 8-4-79 345614
U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO
R.L.H. 7/29/74
B.V.K. 7/29/74
W.P.R. 7/29/74
7/29/74
C.O.S. 7/29/74
ZEFF, COGORNO & SEALY, INC
TRI-CONSULTANTS, INC
HYDRO-TRIAD, LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
SAMPLING - STRUCTURE
SPILLWAY & OUTLET PLAN
AS SHOWN
D 27318-3
9 • 12



END VIEW
SCALE: 1"=5'
PLAN-INLET STRUCTURE
SCALE: 1"=5'
27318-3
Note:
See sections & details for reinforcement
PLAN-IMPACT STILLING BASIN & SAMPLING VALVE BOX
SCALE: 1"=2'
27318-3
IMPACT STILLING BASIN STA 2+30
℄ VALVE BOX STA 2+19
DETAIL-"3"
SCALE 1"=2'
SECTION A-A
SCALE: 1"=5'
SECTION D-D
SCALE: 1"=2'
30" Manhole Ring & Cover w/Lifting Ring Camco C-5088 or equal
48" dia. precast cover w/30" opening
DETAIL-"4"
SCALE NONE
MH WALL
COUPLING
GASKET
10" DIP
ANCHOR BOLT W/NUT & WASHER
SECTION B-B
SCALE: 1"=3'
SECTION C-C
SCALE: 1"=3'
DETAIL-"2"
SCALE: 1"=2'
DETAIL "1"
SCALE: 1"=2'
TRASH RACK
SCALE: 1"=2'
PLAN-INLET STRUCTURE
SCALE: 1"=2'
27318-3
Note:
Trashrack omitted for clarity
10" Dresser Model "450" Butterfly Valve Mechanical Joint, Underground Operator.
SECTION E-E
SCALE: 1"=2'
Note:
All reinforcement #4 @12" C-C, 2" clear
0
ORIGINAL ISSUE
345614
U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO
RLH 7/29/74
BVK 7/29/74
WPR 7/29/74
7/29/74
ZEFF, COGORNO & SEALY, INC.
TRI-CONSULTANTS, INC.
HYDRO-TRIAD, LTD.
Denver, Colo.
SANITARY LANDFILL RENOVATIONS
SAMPLING - STRUCTURE
SPILLWAY & OUTLET DETAILS
AEC CONT. NO.
AT(29-2)-3442
SCALE
AS SHOWN
C-S 7/30/74
D
27318-4
10 of 12



NOTE:
1. Fences to be removed by others
2. = Improved section of roadway (this contract)
3. = Unimproved or abandoned roadway.

● BORINGS DRILLED BY ZEFF, COGORNO & SEALY, INC
■ TEST PITS DUG BY ZEFF, COGORNO & SEALY, INC.

PLAN TO BE USED FOR LOCATIONS OF BORINGS NOT FOR CONSTRUCTION.

0	ORIGINAL ISSUE		8-4-74		[signature]	[signature]	345614

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

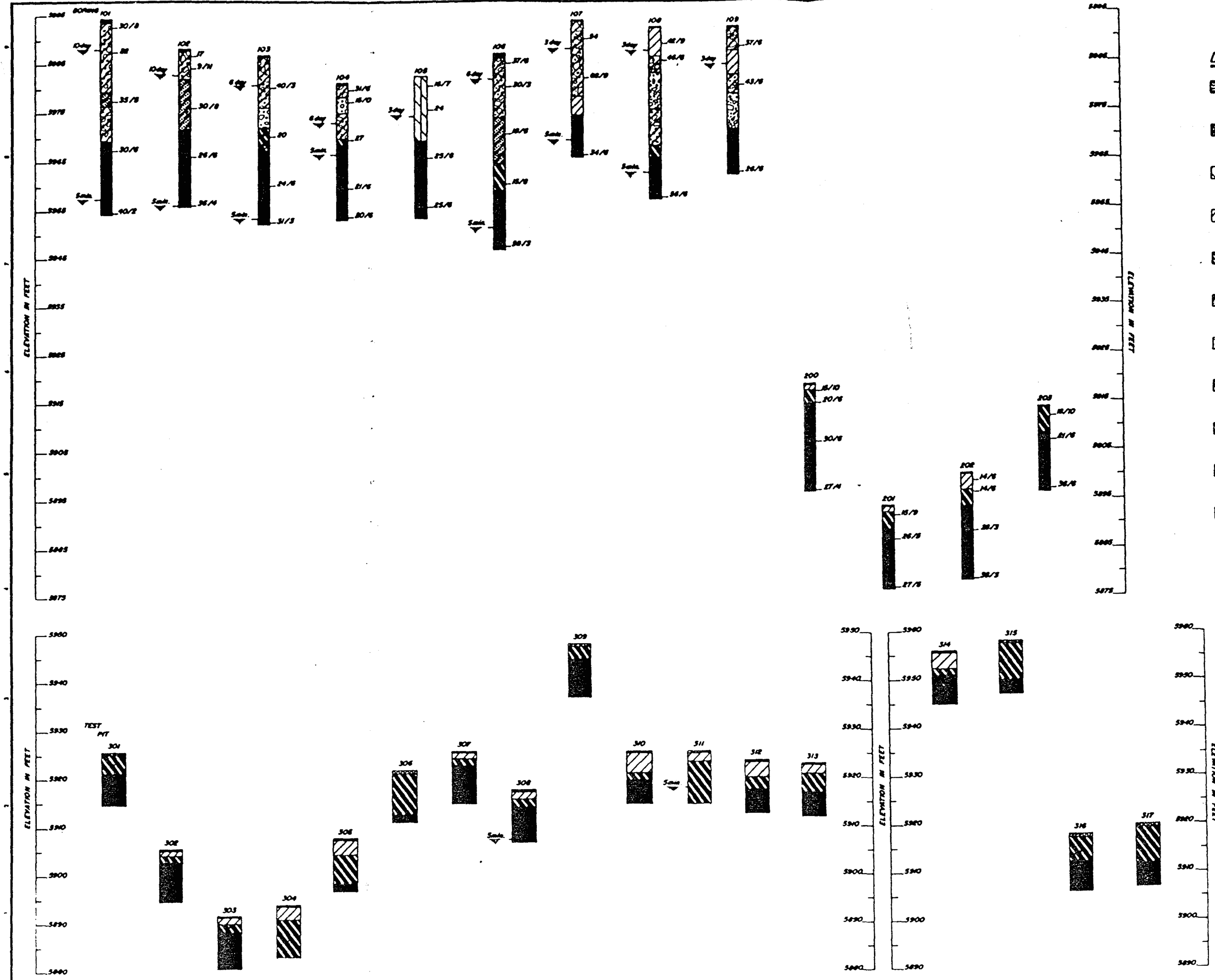
	BY	DATE
	RLH	7/29/74
	JMO	7/29/74
	RLH	7/29/74
	[signature]	7/29/74
	CJS	7/29/74
	[signature]	7/29/74
	[signature]	7/29/74

ZEFF, COGORNO & SEALY INC
TRI-CONSULTANTS INC
HYDRO-TRIAD LTD — Denver, C...

SANITARY LANDFILL RENOVATIONS
TEST BORING AND
TEST PIT LOCATION PLAN

AEC CONT NO. AT(29-2)1342
SCALE 1" = 100'

D 27318-5 — 11 of 12



LEGEND:

- TOPSOIL
- FILL - CLAY, SANDY WITH GRAVELS AND COBBLES
- SANITARY LANDFILL
- ALLUVIUM CONSISTING OF MIXTURES OF CLAYS, SANDS AND GRAVELS WITH RANDOM AMOUNTS OF COBBLES AND BOULDERS
- CLAY, SANDY TO VERY SANDY, SILTY, VERY STIFF, MEDIUM MOIST TO MOIST, BROWN, GRAVEL
- SAND, CLAYEY WITH CLAY LAYERS, MEDIUM DENSE TO DENSE, MEDIUM MOIST TO WET, RANDOM GRAVELS AND COBBLES
- SAND AND GRAVEL, DENSE TO VERY DENSE, MEDIUM MOIST TO WET, SOME COBBLES AND BOULDERS
- SAND AND GRAVEL, SLIGHTLY CLAYEY TO CLAYEY, DENSE TO VERY DENSE, SOME COBBLES AND BOULDERS
- CLAY (SEVERELY WEATHERED CLAYSTONE), VERY STIFF, MOIST
- CLAYSTONE BEDROCK (SHALE), WEATHERED, MEDIUM HARD TO VERY HARD, MOIST, MULTICOLORED, YELLOW, BROWN AND GRAY
- CLAYSTONE BEDROCK (SHALE), WEATHERED, HARD TO VERY HARD, MOIST, YELLOW AND GRAY
- WATER TABLE, TIME AFTER DRILLING

NOTES:

(1). THE BORINGS WERE DRILLED MAY 28 THROUGH JUNE 3, 1974, WITH A 4" DIAMETER, CONTINUOUS FLIGHT, POWER AUGER.

(2). THE TEST PITS WERE DUG MAY 30 AND 31, 1974 WITH A BACKHOE.

(3). 30 INDICATES THAT 30 BLOWS OF A 140-LB. HAMMER FALLING 30" WERE REQUIRED TO DRIVE THE SAMPLER 6".

(4). THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

(5). THE BORING LOGS SHOW SUBSURFACE CONDITIONS AT THE DATES AND LOCATIONS INDICATED, AND IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

0	ORIGINAL ISSUE		8-4-74			345614
ISSUE	DESCRIPTION		DATE	BY	APPV'D	JOB NO.

U. S. ATOMIC ENERGY COMMISSION
ROCKY FLATS AREA OFFICE — GOLDEN, COLORADO

	BY	DATE
DESIGNED	R L H	7/29/74
DRAWN	JTO	7/29/74
CHECKED	R L H	7/29/74
APPROVED		7/29/74
SUBMITTED		7/29/74
APP'D		
APP'D		11-4-74

ZEFF, COGORNO & SEALY, INC
TRI-CONSULTANTS, INC
HYDRO-TRIAD, LTD
Denver, Colo

SANITARY LANDFILL RENOVATIONS
LOGS OF EXPLORATORY BORINGS
AND TEST PITS

AEC CONT. NO. AT(29-2)3442
SCALE 1"=10'

SIZE D — DRAWING NUMBER 27318-6 — SHEET 12 - 12

UNITED STATES

DEPARTMENT OF ENERGY

ALBUQUERQUE OPERATIONS OFFICE

ROCKY FLATS AREA OFFICE

SANITARY LANDFILL EXTENSION SLURRY TRENCH

WRIGHT-McLAUGHLIN ENGINEERS
in conjunction with
A. G. WASSENAAR, INC.
2420 ALCOTT ST. DENVER, COLORADO

INVITATION NO.
DE-AC04-82AL18828

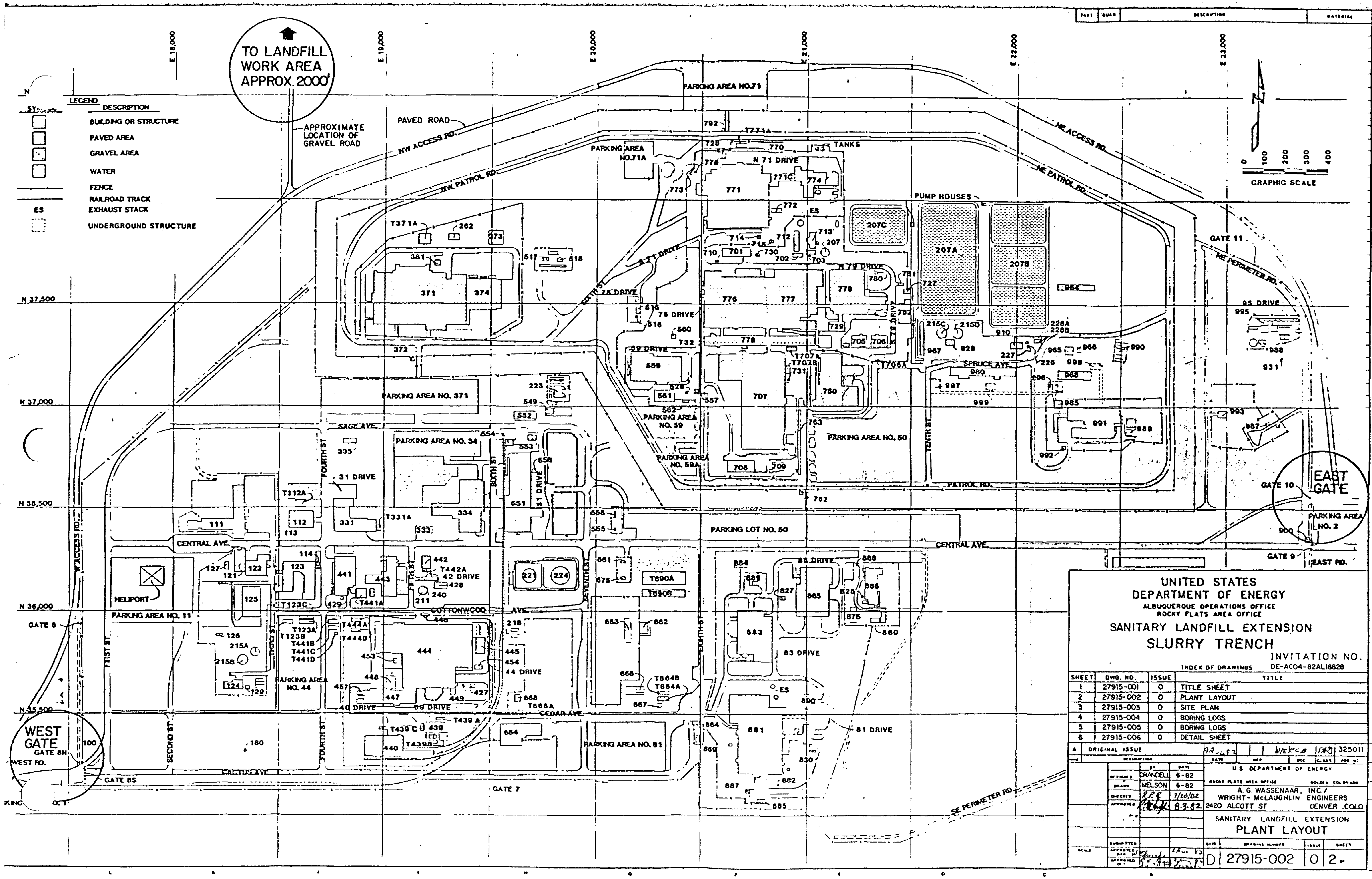
INDEX OF DRAWINGS

0 ORIGINAL ISSUE 9 AUG '82 ... 325011

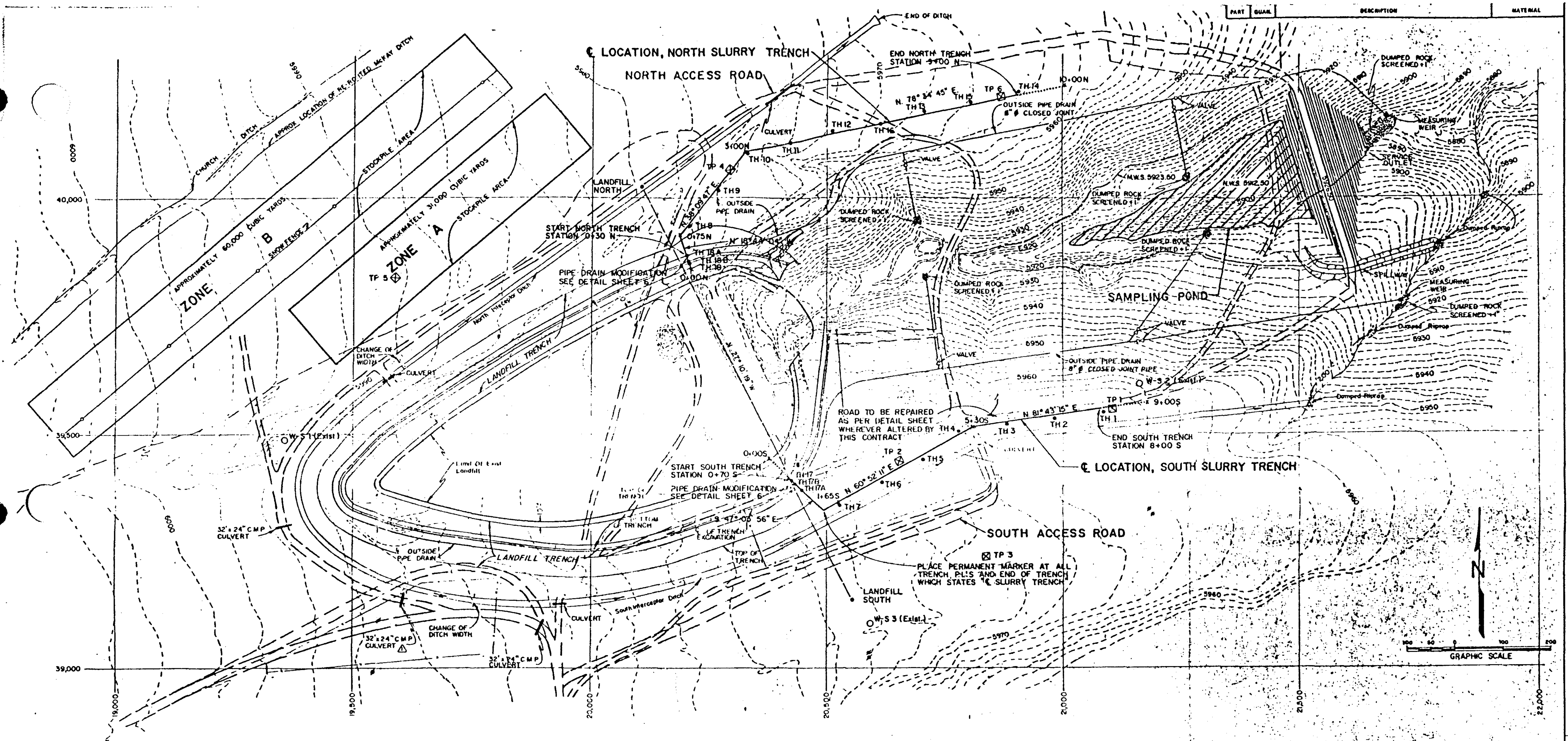
DESIGNED CRANDEL 6-82
DRAWN NELSON 6-82
CHECKED 7/29/82
APPROVED 8-3-82

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
A. G. WASSENAAR, INC. / WRIGHT-McLAUGHLIN ENGINEERS
2420 ALCOTT ST. DENVER, COLO.
SANITARY LANDFILL EXTENSION
TITLE SHEET

SIZE D | DRAWING NUMBER 27915-001 | ISSUE 0 | SHEET 1 of 6



TO LANDFILL WORK AREA APPROX. 2000'
APPROXIMATE LOCATION OF GRAVEL ROAD
PAVED ROAD
LEGEND
DESCRIPTION
BUILDING OR STRUCTURE
PAVED AREA
GRAVEL AREA
WATER
FENCE
RAILROAD TRACK
ES
EXHAUST STACK
UNDERGROUND STRUCTURE
GRAPHIC SCALE
0 100 200 300 400
E 18,000
E 19,000
E 20,000
E 21,000
E 22,000
E 23,000
N 37,500
N 37,000
N 36,500
N 36,000
N 35,500
NW ACCESS RD.
NW PATROL RD.
NE ACCESS RD.
NE PATROL RD.
NE PERIMETER RD.
SE PERIMETER RD.
W ACCESS RD.
PARKING AREA NO.71
PARKING AREA NO.71A
PARKING AREA NO. 371
PARKING AREA NO. 34
PARKING AREA NO. 59
PARKING AREA NO. 59A
PARKING AREA NO. 50
PARKING LOT NO. 50
PARKING AREA NO. 11
PARKING AREA NO. 44
PARKING AREA NO. 81
PARKING AREA NO. 2
PUMP HOUSES
TANKS
HELIPORT
EAST GATE
WEST GATE
GATE 6
GATE 7
GATE 8N
GATE 8S
GATE 9
GATE 10
GATE 11
WEST RD.
EAST RD.
CENTRAL AVE.
CACTUS AVE.
CEDAR AVE.
COTTONWOOD AVE.
SAGE AVE.
SPRUCE AVE.
PATROL RD.
FIRST ST
SECOND ST.
THIRD ST
FOURTH ST
FIFTH ST
SIXTH ST
SEVENTH ST
EIGHTH ST
TENTH ST
31 DRIVE
42 DRIVE
44 DRIVE
40 DRIVE
49 DRIVE
51 DRIVE
59 DRIVE
76 DRIVE
78 DRIVE
79 DRIVE
N 71 DRIVE
81 DRIVE
83 DRIVE
88 DRIVE
95 DRIVE
UNITED STATES
DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE
ROCKY FLATS AREA OFFICE
SANITARY LANDFILL EXTENSION
SLURRY TRENCH
INVITATION NO.
DE-AC04-82AL18828
INDEX OF DRAWINGS
SHEET | DWG. NO. | ISSUE | TITLE
1 | 27915-001 | 0 | TITLE SHEET
2 | 27915-002 | 0 | PLANT LAYOUT
3 | 27915-003 | 0 | SITE PLAN
4 | 27915-004 | 0 | BORING LOGS
5 | 27915-005 | 0 | BORING LOGS
6 | 27915-006 | 0 | DETAIL SHEET
A | ORIGINAL ISSUE
325011
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE
GOLDEN, COLORADO
DESIGNED CRANDELL 6-82
DRAWN NELSON 6-82
CHECKED 7/20/82
APPROVED 8-3-82
A. G. WASSENAAR, INC./
WRIGHT-McLAUGHLIN ENGINEERS
2420 ALCOTT ST
DENVER, COLO
SANITARY LANDFILL EXTENSION
PLANT LAYOUT
D 27915-002 0 2



TEST HOLE COORDINATES

LOCATION	NORTH	EAST	ELEVATION
TH1	39545.5	21082.0	5966.4
TH2	39532.0	20981.5	5967.6
TH3	39519.0	20882.5	5969.6
TH4	39505.5	20781.5	5970.9
TH5	39444.5	20702.5	5972.3
TH6	39397.0	20615.5	5974.2
TH7	39348.5	20527.0	5976.3
TH8	39945.5	20201.5	5978.2
TH9	40018.0	20264.5	5976.4
TH10	40097.0	20326.0	5975.9
TH11	40126.0	20425.5	5974.5
TH12	40145.0	20510.5	5972.4
TH13	40184.0	20708.5	5968.7
TH14	40225.5	20909.5	5965.0
TH15	40203.5	20807.0	5966.9
TH16	40156.0	20617.5	5970.0
TH17	39400.0	20417.5	5974.7
TH17A	39395.5	20428.5	5975.7
TH17B	39400.0	20425.0	5974.5
TH18	39864.0	20202.5	5976.0
TH18A	39881.0	20197.0	5975.7
TH18B	39871.0	20200.0	5975.7

TEST PIT COORDINATES

LOCATION	NORTH	EAST	ELEVATION
TP 1	39554.0	21105.0	5966.2
TP 2	39442.5	20655.0	5972.3
TP 3	39258.0	20859.0	5970.3
TP 4	40061.0	20290.0	5976.9
TP 5	39835.0	19588.0	5997.7
TP 6	40216.0	20473.0	5966.3

STATION COORDINATES

STATION	NORTH	EAST
STA 0+00N	39857.75	20206.45
STA 0+75N	39925.78	20182.34
STA 5+00N	40100.69	20521.57
STA 10+00N	40259.50	21007.51
STA 0+00S	39448.88	20572.68
STA 1+65S	39350.49	20693.48
STA 5+30S	39514.17	20812.51
STA 9+00S	39567.45	21178.46

BENCH MARK COORDINATES

	NORTH	EAST	ELEVATION
LANDFILL NORTH	40020.76	20101.93	5979.62
LANDFILL SOUTH	39140.55	20553.75	5976.57

NOTES:

"LANDFILL NORTH" IS A #3 REBAR THAT PROJECTS 3" ABOVE THE GROUND, ON THE NORTH SIDE OF THE LANDFILL, 293' SOUTHWEST OF A CULVERT FOR THE NORTH INTERCEPTOR DITCH, ON THE MIDDLE OF THE BERM BETWEEN ROAD AND DITCH, 18' SOUTHEAST OF CENTER OF ROAD, 12' NORTHWEST OF CENTER OF DITCH.

"LANDFILL SOUTH" IS A #3 REBAR THAT PROJECTS 1" ABOVE THE GROUND, ON THE SOUTH SIDE OF THE LANDFILL, 121.5' SOUTH SOUTHEAST OF THE CENTER OF THE ROAD, 113.0' NORTH NORTHWEST OF THE NORTH POLE OF A DOUBLE POWER LINE POLE, IN RANGE WITH THE WEST EDGE OF NORTH POLE AND THE HIGHEST STACK OF THE 700 COMPLEX.

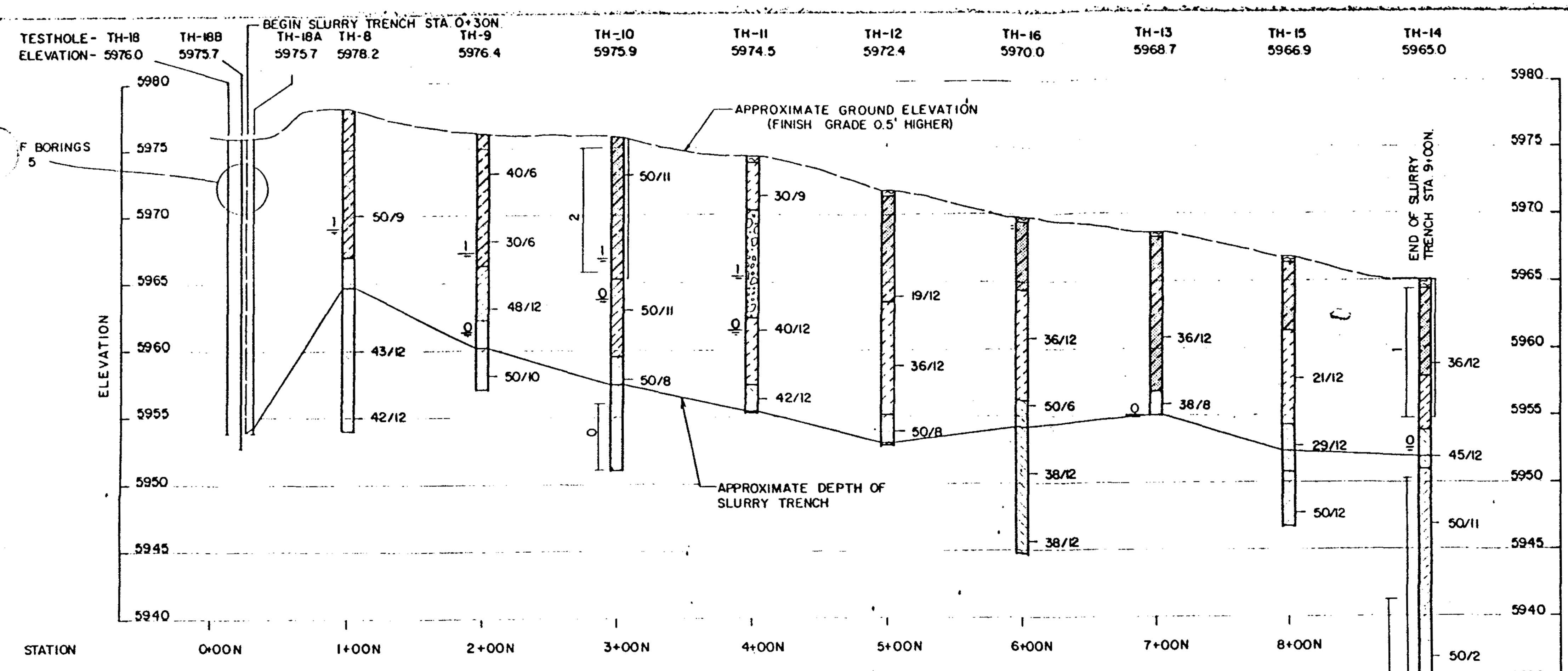
NOTES:

EXISTING SITE CONDITIONS SHOWN AS LIGHT BACKGROUND
TOPOGRAPHIC ELEVATIONS ARE ONLY APPROXIMATE
- TH 1 TEST HOLE
- TP 1 TEST PIT
- O W-S1 GROUNDWATER MONITORING HOLE
- .... COMPLETION OF ORIGINAL SURVEY LINE

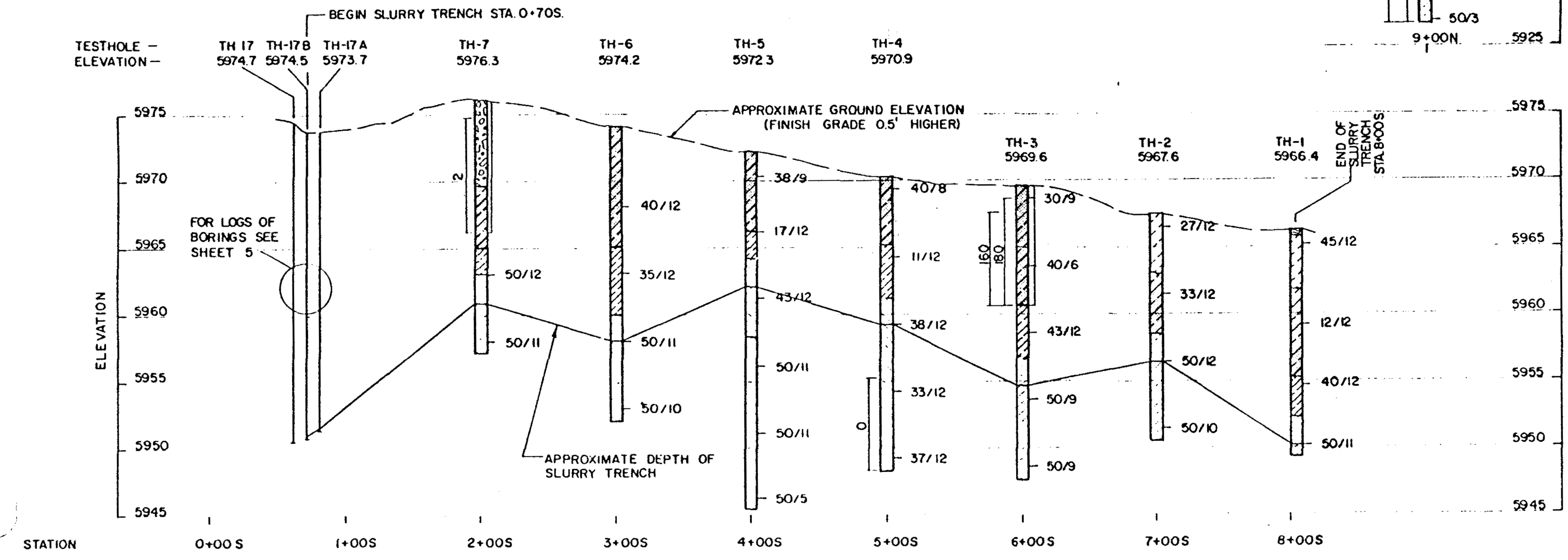
ISSUE	DESCRIPTION	DATE		DOE	CLASS	JOB NO.
0	ORIGINAL ISSUE	9Aug82		WTE RCB	[illegible]	325011

TOLERANCES		BY	DATE	
FRACT. ± ANGLE ± DEC. ±	DESIGNED	CESARE	6-82	U.S. DEPARTMENT OF ENERGY — ROCKY FLATS AREA OFFICE, GOLDEN, COLORADO
UNLESS NOTED OTHERWISE	DRAWN	FRAGUA	6-82	A. G. WASSENAAR, INC / WRIGHT-McLAUGHLIN ENGINEERS
	CHECKED	RLB	7/20/82	2420 ALCOTT ST, DENVER, COLO
REMOVE BURRS AND SHARP EDGES	APPROVED	[signature]	8.5.82	SANITARY LANDFILL EXTENSION
NEXT ASSEMBLY				SITE PLAN
DOE CONT. NO.	SUBMITTED			
	APPROVED RFP	[signature]	4 Aug 82	
SCALE 1" = 100'	APPROVED DOE	[signature]	4 Aug	

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-003	0	3 OF



NORTH LINE OF SLURRY TRENCH



SOUTH LINE OF SLURRY TRENCH

NOTE:
LEGEND ON SHEET 5

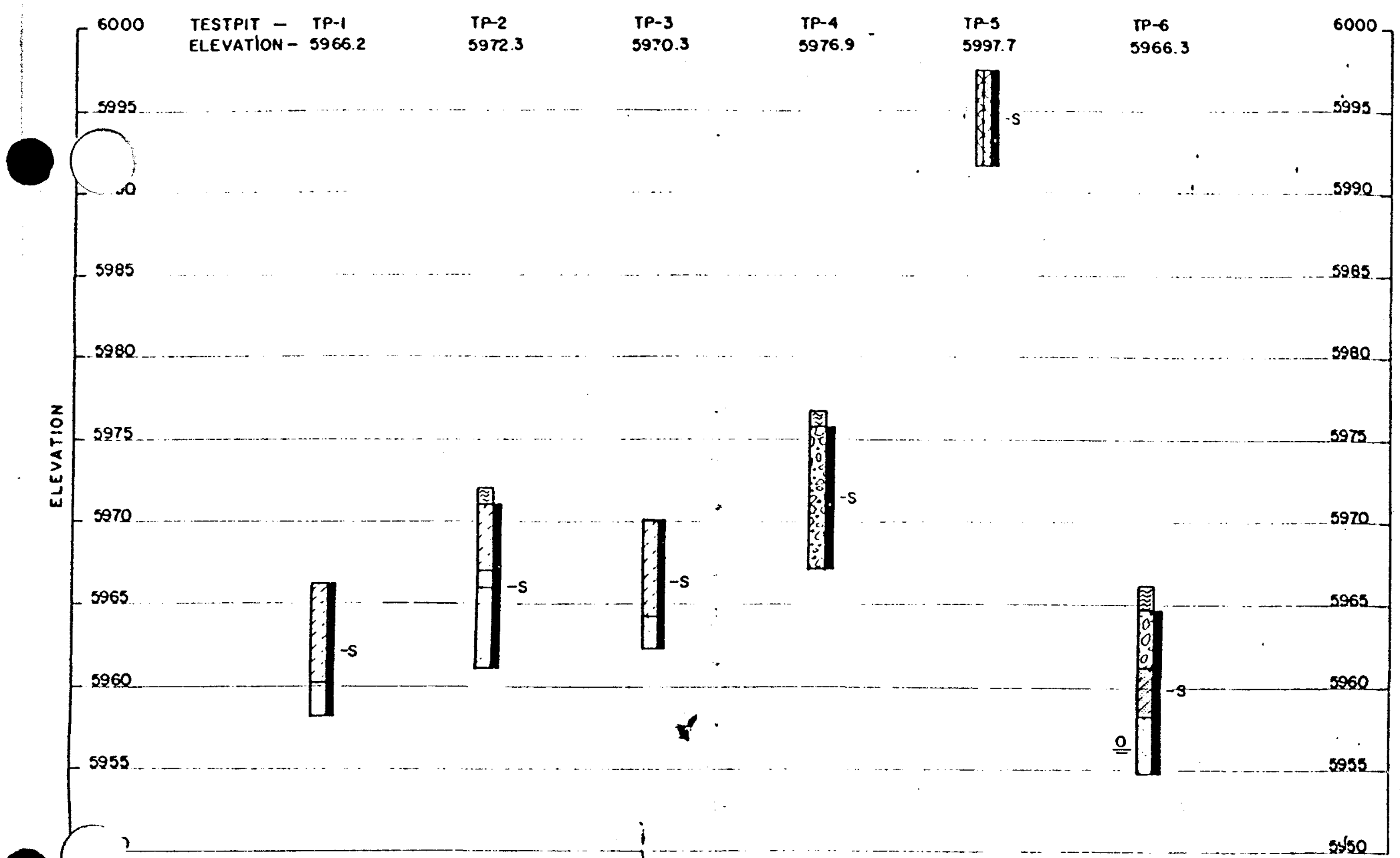
PART	QUAN.	DESCRIPTION	MATERIAL

ISSUE	DESCRIPTION	BY	DATE	DATE	DOE	CLASS	JOB NO
0	ORIGINAL ISSUE			9 Aug '82			325011

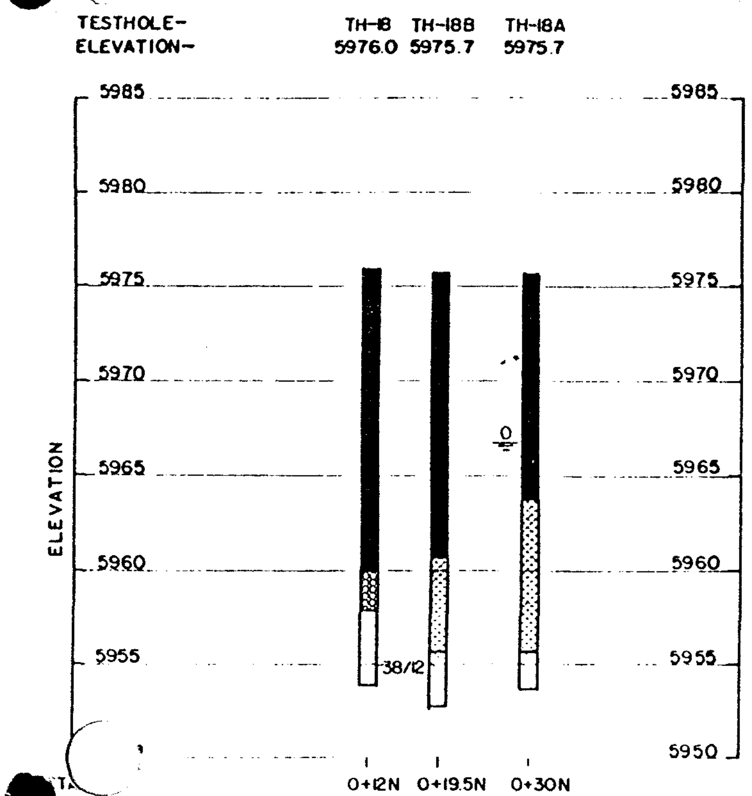
TOLERANCES FRACT ± ANGLE ± DEC ±	DESIGNED	CESARE	6-82
UNLESS NOTED OTHERWISE	DRAWN	FRAGUA	6-82
REMOVE BURRS AND SHARP EDGES	CHECKED		7/28/82
NEXT ASSEMBLY	APPROVED		8-3-82
DOE CONT NO	SUBMITTED		
SCALE N/A	APPROVED REP / APPROVED DOE		

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN
A. G. WASSENAAR, INC /
WRIGHT - McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO
SANITARY LANDFILL EXTENSION
BORING LOGS

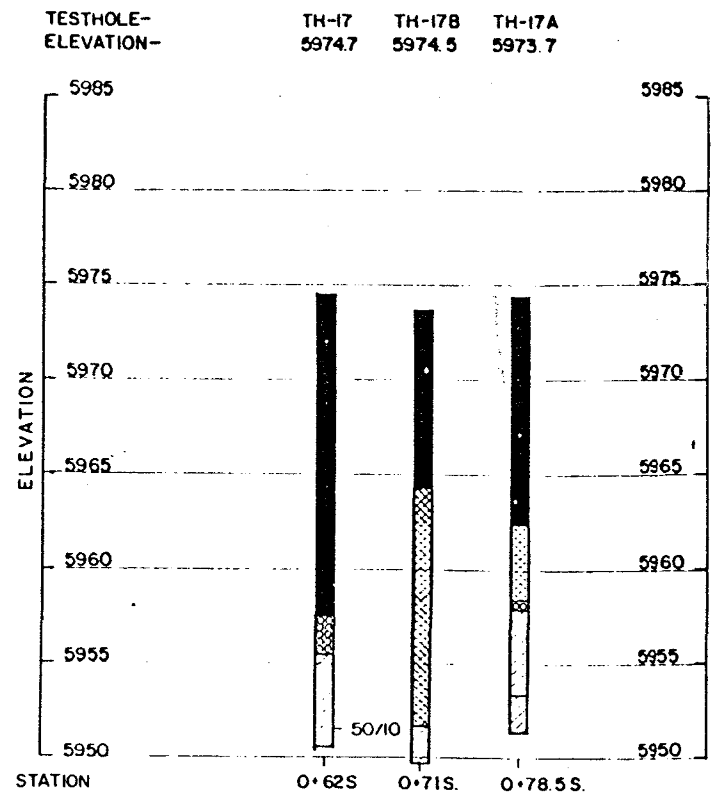
SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-004	0	4 of



TEST PITS



NORTH TIE IN LINE



SOUTH TIE IN LINE

LEGEND:

TOPSOIL	ORGANIC, SANDY TO VERY SANDY, SILTY TO VERY SILTY, SOME GRAVELLS AND COBBLES, DRY TO MOIST, BROWN TO DARK BROWN (OL, CL, GC).
FILL	CLAY, SANDY TO VERY SANDY, GRAVELLY, SLIGHTLY SILTY, OCCASIONAL COBBLES AND BOULDERS, MOIST, RED-BROWN (CL, CL-CH, ZONE A BORROW AREA)
LANDFILL DEBRIS	SANDY, CLAYEY, SILTY, WITH WOOD, BRICK, GLASS, METAL AND GENERAL CONSTRUCTION DEBRIS, GENERALLY UNCONSOLIDATED (AF).
FILL	CLAYEY, SLIGHTLY SILTY, SLIGHTLY SANDY, SOFT TO MEDIUM STIFF, MOIST TO WET, BROWN TO GRAY (CL) (PROBABLE LINER MATERIAL FOR EXISTING LANDFILL TRENCH SECTION).
CLAY	ARKOSIC, VERY STIFF, SILTY, SANDY TO VERY SANDY WITH SAND LENSES, GRAVELLY WITH OCCASIONAL GRAVEL LENSES, OCCASIONAL COBBLES AND BOULDERS, CALCAREOUS, DRY TO MOIST, REDDISH BROWN TO DARK BROWN (CL, CL-SC, GC) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
SAND	ARKOSIC, MEDIUM DENSE TO VERY DENSE, SILTY TO VERY SILTY, SLIGHTLY TO VERY CLAYEY WITH SANDY CLAY LENSES, GRAVELLY WITH GRAVEL LENSES, OCCASIONAL COBBLES AND BOULDERS, CALCAREOUS, MOIST TO WET, TAN TO BROWN TO OLIVE (SM, SM-SC, SC) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
GRAVEL	VERY DENSE, SANDY TO VERY SANDY, CLAYEY, DRY TO MOIST, GRAY TO BROWN (GC, GC-GP) (ROCKY FLATS ALLUVIUM, HIGHLY WEATHERED)
GRAVEL	DENSE, SANDY, CLAYEY, GRAY, APPROXIMATELY 1/2" TO 1" DIAMETER (GM-GP) (PROBABLE LINER MATERIAL FOR LANDFILL TRENCH SECTION)
CLAY	ARKOSIC, VERY STIFF, SANDY WITH CLAYEY SAND LENSES, SILTY TO VERY SILTY, MOIST TO WET, GRAY TO GOLD TO OLIVE (CH, CL, SC-SM) (ARAPAHOE FORMATION, WEATHERED)
CLAYSTONE	HARD TO VERY HARD, WITH OCCASIONAL SANDSTONE AND SILTSTONE LENSES, SOME MINOR LIGNITE, MOIST TO WET, GRAY TO BROWN (ARAPAHOE FORMATION)
CLAYSTONE	MEDIUM HARD, SANDY WITH OCCASIONAL SANDSTONE AND SILTSTONE LENSES, MOIST, OLIVE TO BROWN TO GOLD, ARKOSIC IN UPPER PORTION (ARAPAHOE FORMATION)
50/9	INDICATES THAT 50 BLOWS OF A 140 LB. WEIGHT IS NEEDED TO DRIVE A 2 INCH SAMPLER 9 INCHES
	INDICATES A GRADUAL CHANGE IN MATERIALS
8	INDICATES LARGE BULK SAMPLE OF MATERIAL TAKEN FROM DESIGNATED INTERVAL
2	INDICATES AVERAGE COEFFICIENT OF PERMEABILITY OF 2 FEET PER YEAR FOR DESIGNATED INTERVAL AS DETERMINED BY A FALLING HEAD OR CONSTANT HEAD PERMEABILITY TEST. DETAILS OF TEST RESULTS ARE PRESENTED IN THE CONTRACT DOCUMENTS.
-S	DEPTH AND EXTENT OF BULK SAMPLE
	DEPTH AND EXTENT OF 2-INCH DIAMETER PVC PIEZOMETER

PART	QUAN.	DESCRIPTION	MATERIAL

ISSUE	DESCRIPTION	DATE			DOE	CLASS	JOB NO
0	ORIGINAL ISSUE	7 Aug '8?			WR PCB	??	325011

		BY	DATE
TOLERANCES FRACT. ANGLE DEC.	DESIGNED	CESARE	6-82
UNLESS NOTED OTHERWISE	DRAWN	FRAGUA	6-82
REMOVE BURRS AND SHARP EDGES	CHECKED		7/28/82
NEXT ASSEMBLY	APPROVED		8-3-82
DOE CONT NO.	SUBMITTED		
SCALE N/A	APPROVED REP.		7 Aug ?
	APPROVED DOE		

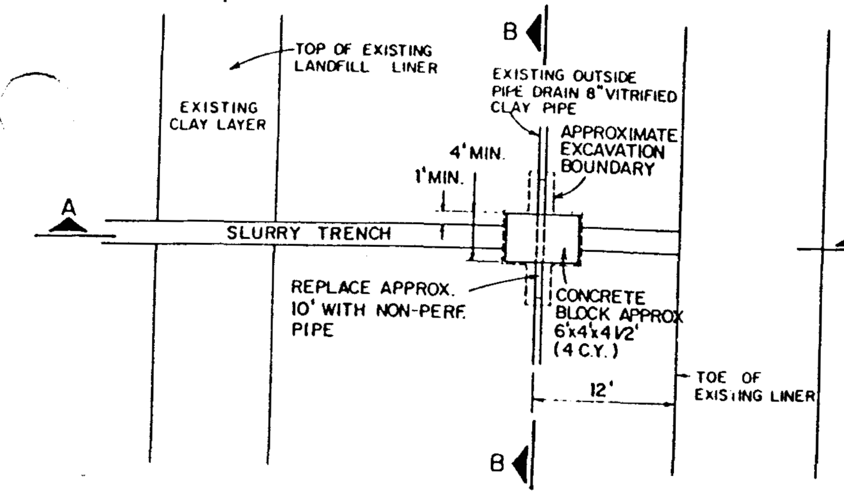
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN COLORADO

A G WASSENAAR, INC /
WRIGHT - McLAUGHLIN ENGINEERS
2420 ALCOTT ST DENVER, COLO

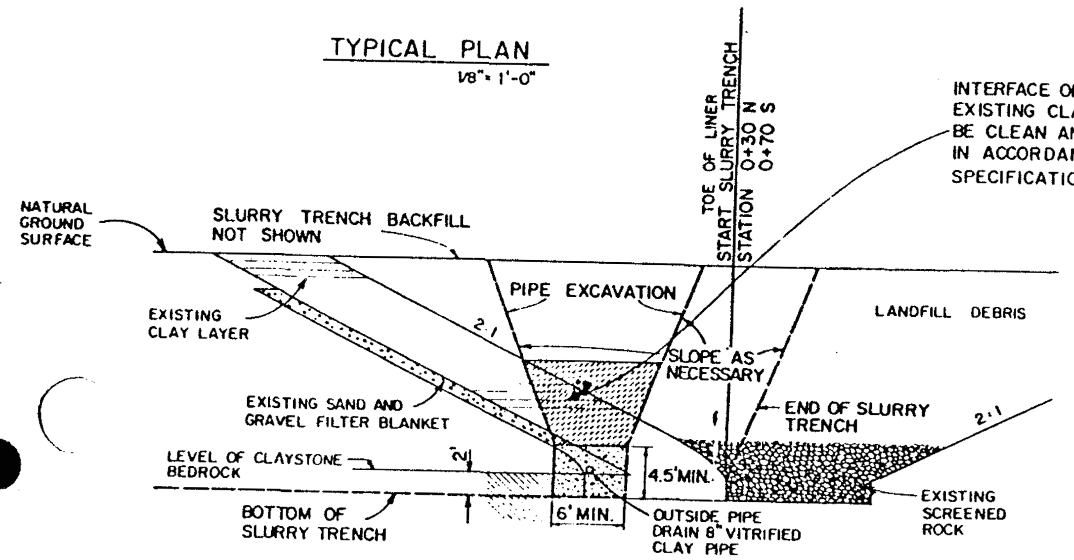
SANITARY LANDFILL EXTENSION

BORING LOGS

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-005	0	5 of

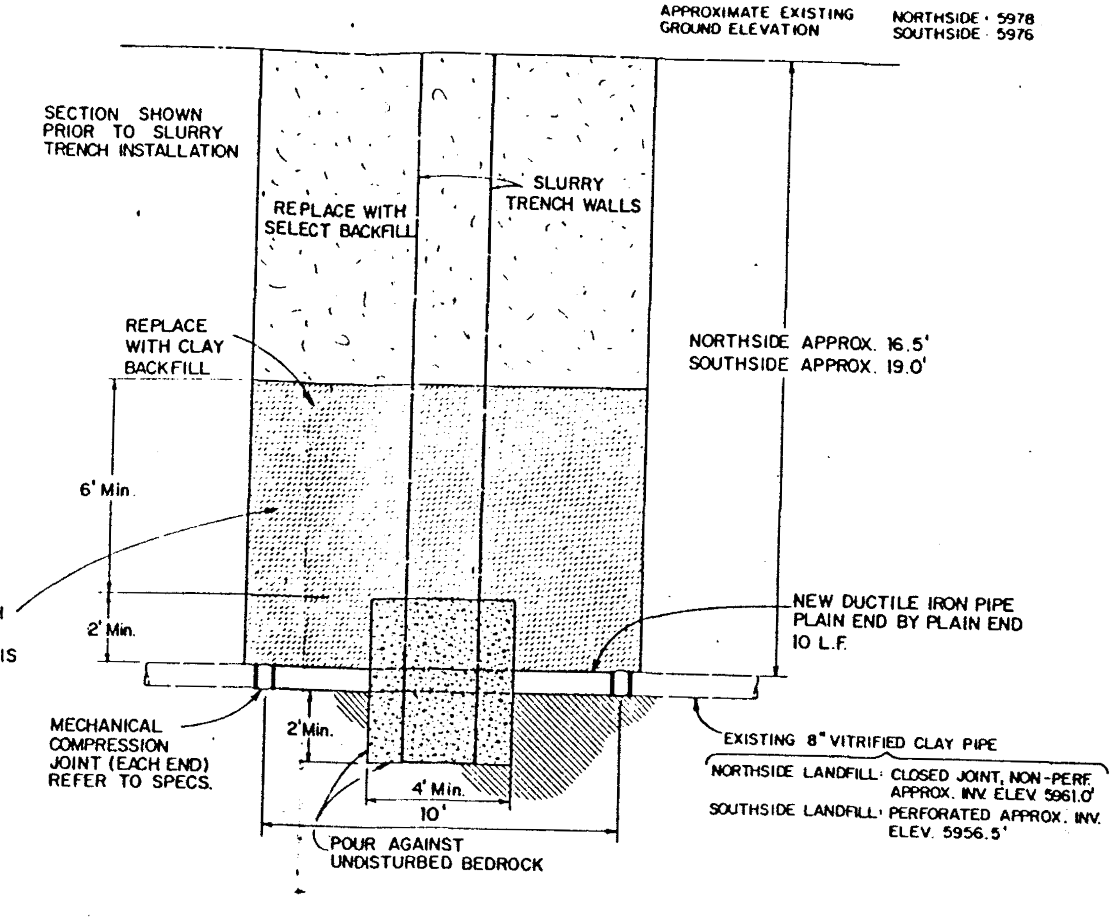


TYPICAL PLAN
1/8" = 1'-0"

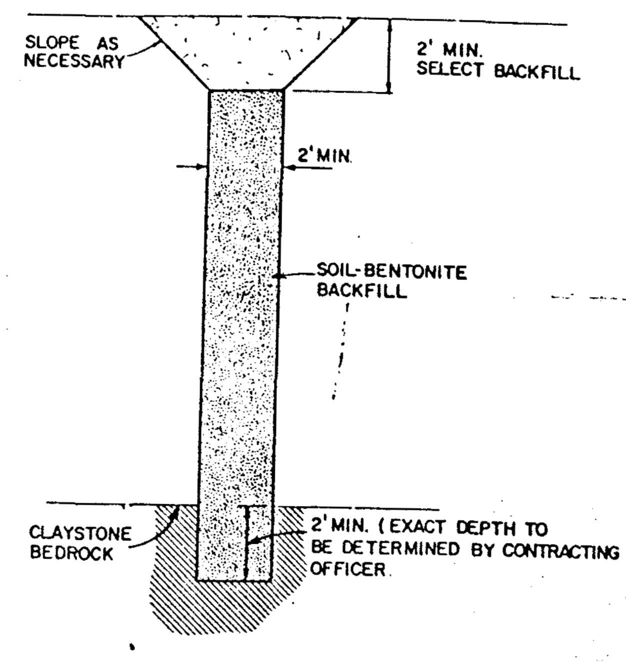


SECTION A-A

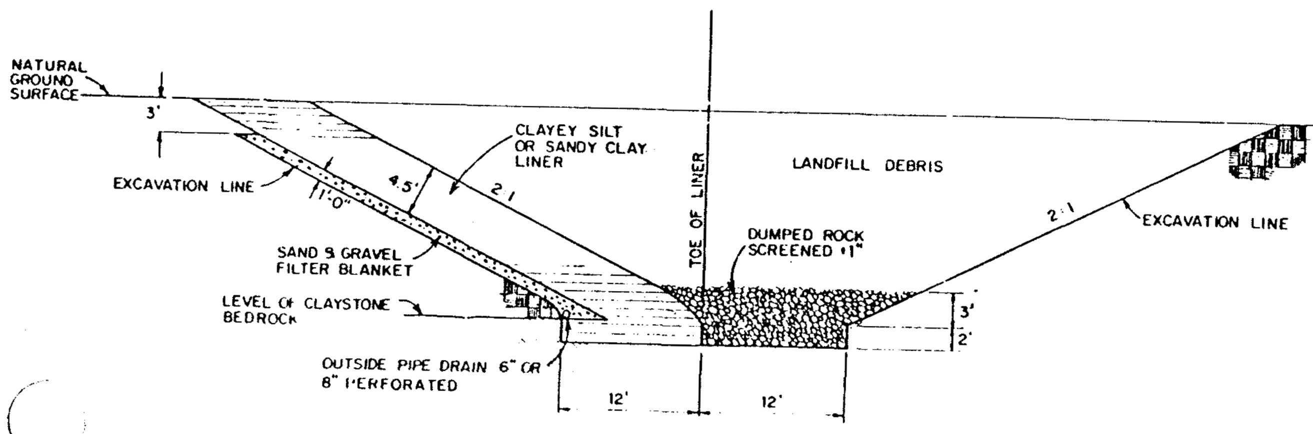
DRAIN PIPE - SLURRY TRENCH INTERSECTION
1/8" = 1'-0" (TYPICAL DETAIL TWO LOCATIONS)



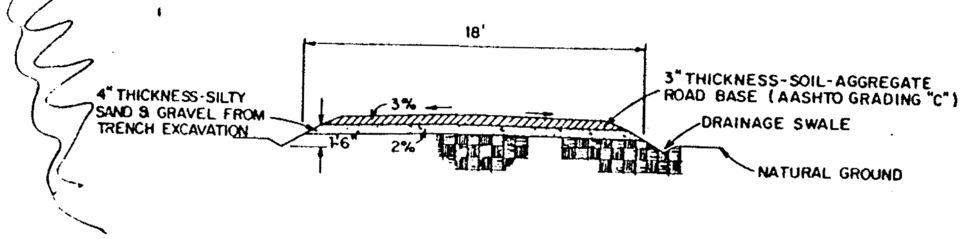
DRAIN PIPE REPLACEMENT SECTION B-B
3/8" = 1'-0"



TYPICAL SLURRY TRENCH DETAIL
NOT TO SCALE



TYPICAL EXISTING LANDFILL LINER SECTION
1/8" = 1'-0"



TYPICAL SECTION ACCESS ROAD REPAIR
1" = 5'

NOTE:
—— PEN SIZE INDICATES EXISTING
—— PEN SIZE INDICATES NEW

ISSUE	DESCRIPTION	DATE		DOE	CLASS	JOB NO
0	ORIGINAL ISSUE	9 Aug 8-		RCB		325011

		BY	DATE
TOLERANCES FRACT ± ANGLE ± DEC ±	DESIGNED	CRANDEL	6-82
UNLESS NOTED OTHERWISE	DRAWN	FRAGUA	6-82
REMOVE BURRS AND SHARP EDGES	CHECKED		7/1/82
NEXT ASSEMBLY	APPROVED		8-3-82
DOE CONT. NO	SUBMITTED		
SCALE SEE DETAIL	APPROVED REP		
	APPROVED DOE		

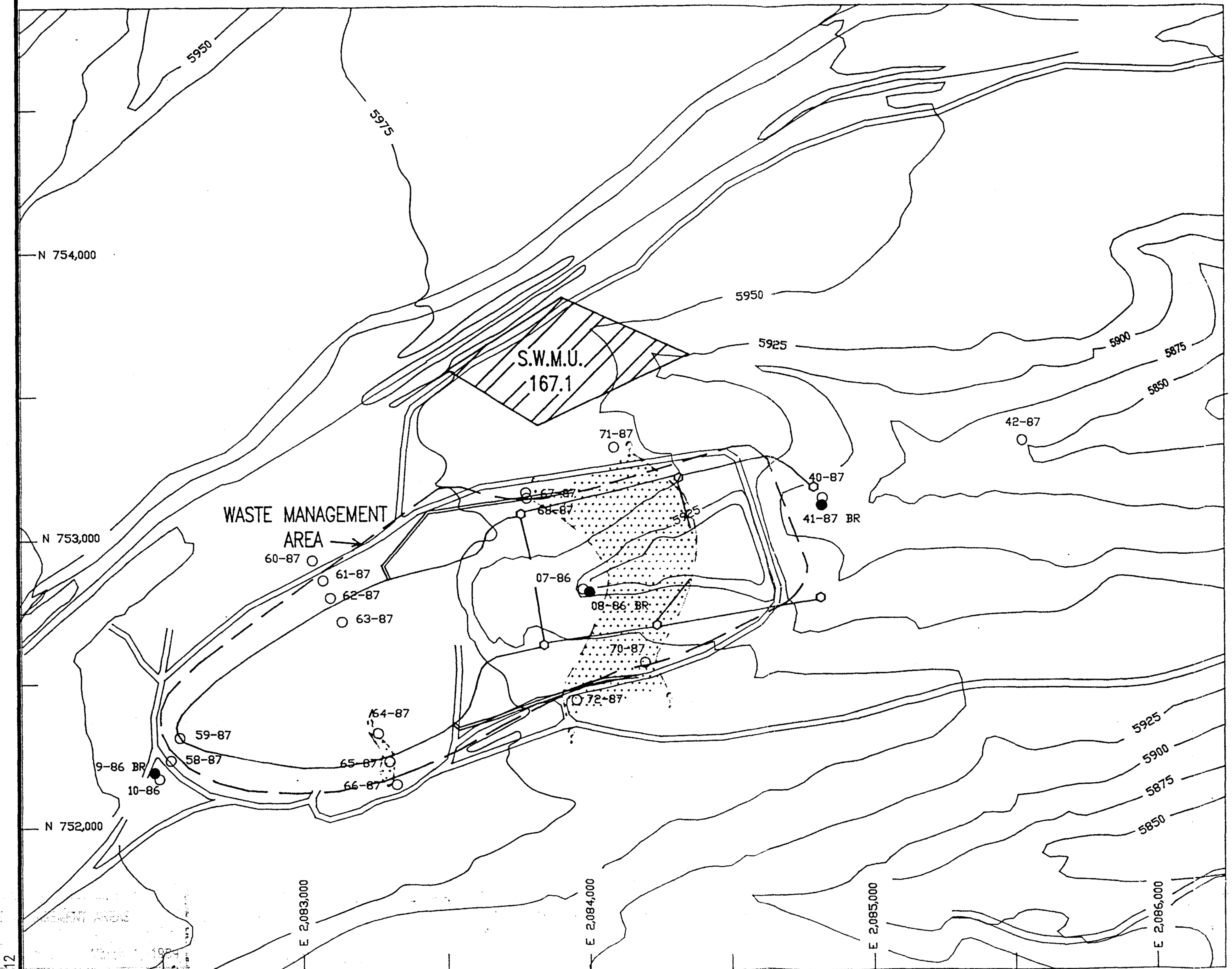
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN COLORADO

A. G. WASSENAAR, INC /
WRIGHT - McLAUGHLIN ENGINEERS
2420 ALCOTT ST. DENVER, COLO

SANITARY LANDFILL EXTENSION
DETAIL SHEET

SIZE	DRAWING NUMBER	ISSUE	SHEET
D	27915-006	0	6 OF

PART	QUAN	DESCRIPTION	MATERIAL



EXPLANATION

- Alluvial Monitoring Well
- Bedrock Monitoring Well
- 45-86 Well Designation
- Valves
- Ground-Water Intercept System
- Slurry Wall
- Waste Management Area
- Subcropping Sandstone (estimated extent)
- Solid Waste Management Unit

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

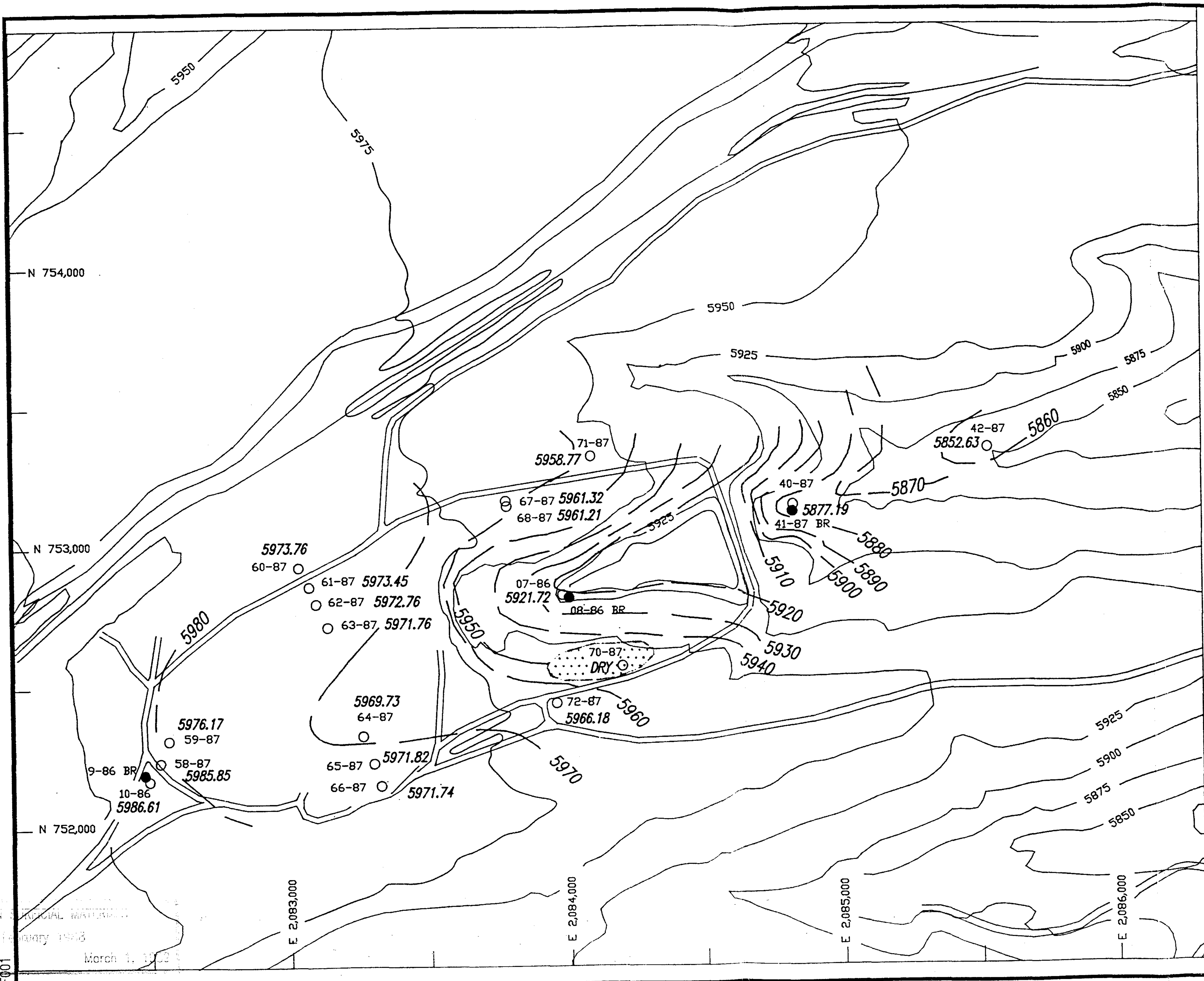
FIGURE 16

Present Landfill

BEDROCK GEOLOGY AND
WASTE MANAGEMENT AREAS

March 1, 1989

LF012



EXPLANATION

○ Alluvial Monitoring Well

● Bedrock Monitoring Well

45-86 Well Designation

6028.62 Potentiometric Surface Elevation (feet above mean sea level)

6000 Line of Equal Potentiometric Surface Elevation (feet above mean sea level – dashed where approximately located)

Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendices E-4 and E-5 for Water Level Data

-N-

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 17

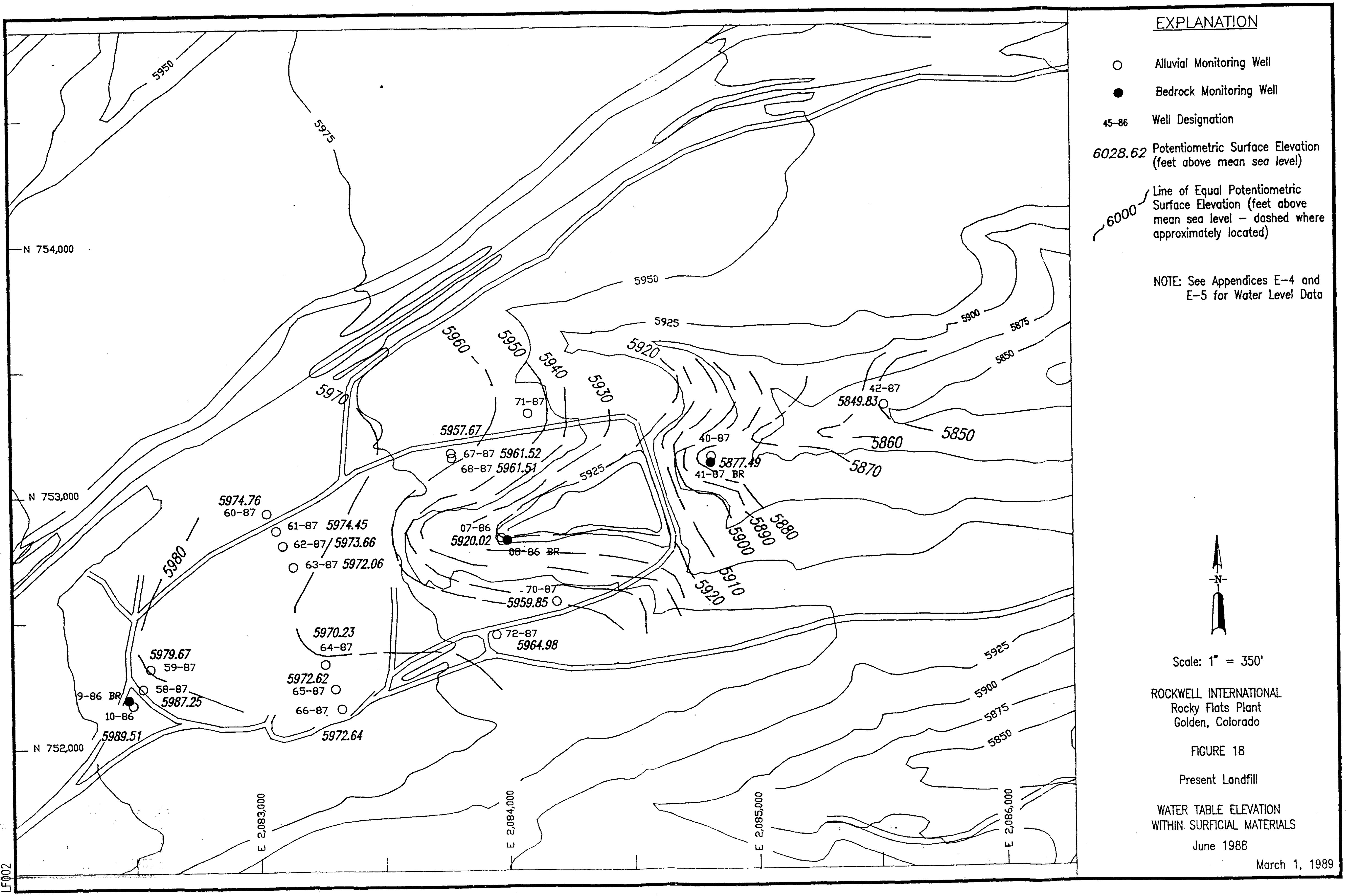
Present Landfill

WATER TABLE ELEVATION
WITHIN SURFICIAL MATERIALS

February 1988

March 1, 1989

LF001



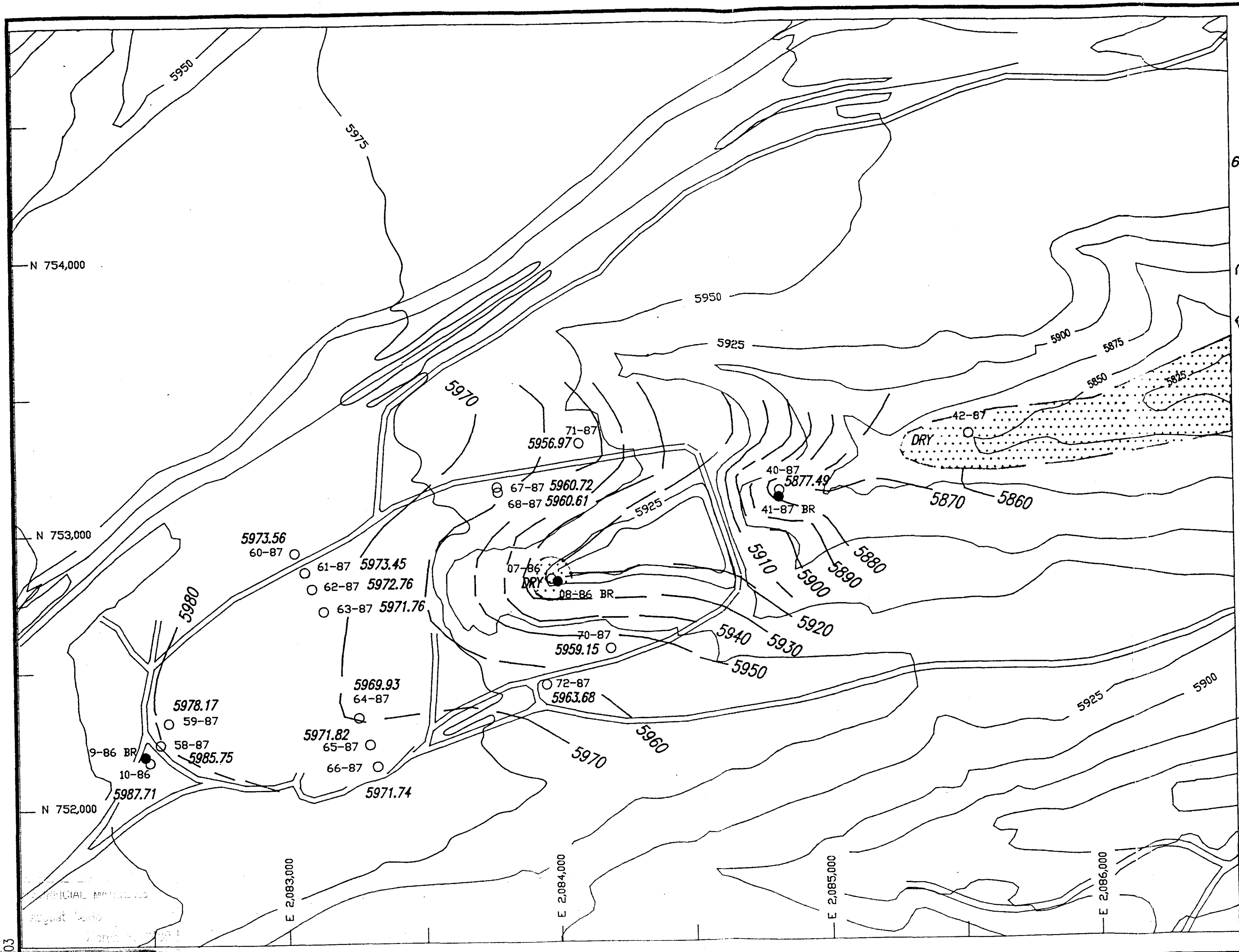
ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 18

Present Landfill

WATER TABLE ELEVATION
WITHIN SURFICIAL MATERIALS
June 1988

March 1, 1989



EXPLANATION

○ Alluvial Monitoring Well

● Bedrock Monitoring Well

45–86 Well Designation

6028.62 Potentiometric Surface Elevation (feet above mean sea level)

6000 Line of Equal Potentiometric Surface Elevation (feet above mean sea level – dashed where approximately located)

Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendices E-4 and E-5 for Water Level Data

N

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 19

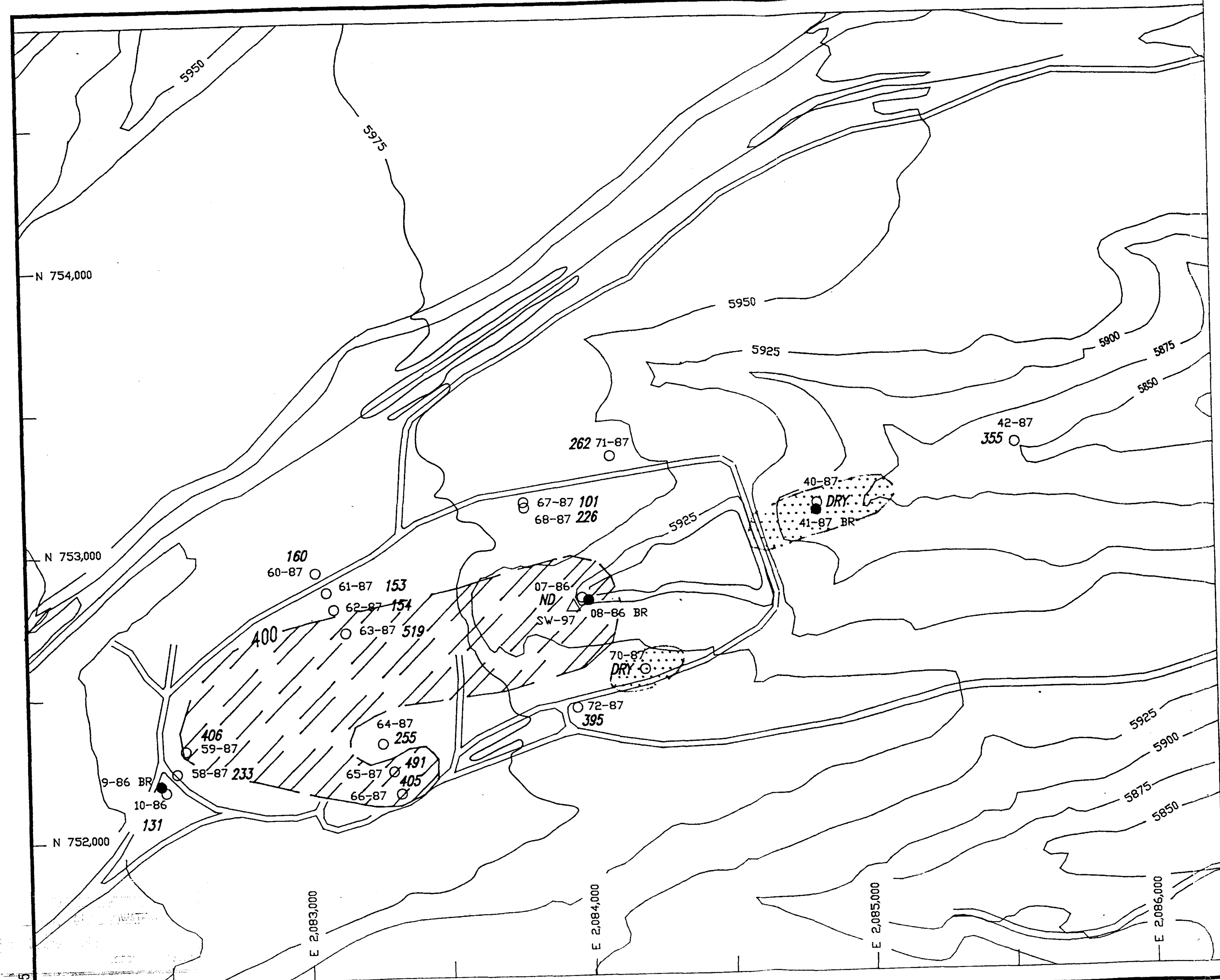
Present Landfill

WATER TABLE ELEVATION WITHIN SURFICIAL MATERIALS

August 1988

March 1, 1989

LF003



EXPLANATION

○ Alluvial Monitoring Well

● Bedrock Monitoring Well

45-86 Well Designation

△ Surface Water Station

ND No Data – Insufficient Sample for Inorganic Analyses

174 Total Dissolved Solids Concentration (mg/l)

400 Line of Equal Total Dissolved Solids Concentration (mg/l) – dashed where approximately located – contour interval varies

Approximate Area of Unsaturated Surficial Materials

Approximate Area of Groundwater Exceeding Proposed Concentration Limit (400 mg/l)

NOTE: See Appendix D for Analytical Data

N

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

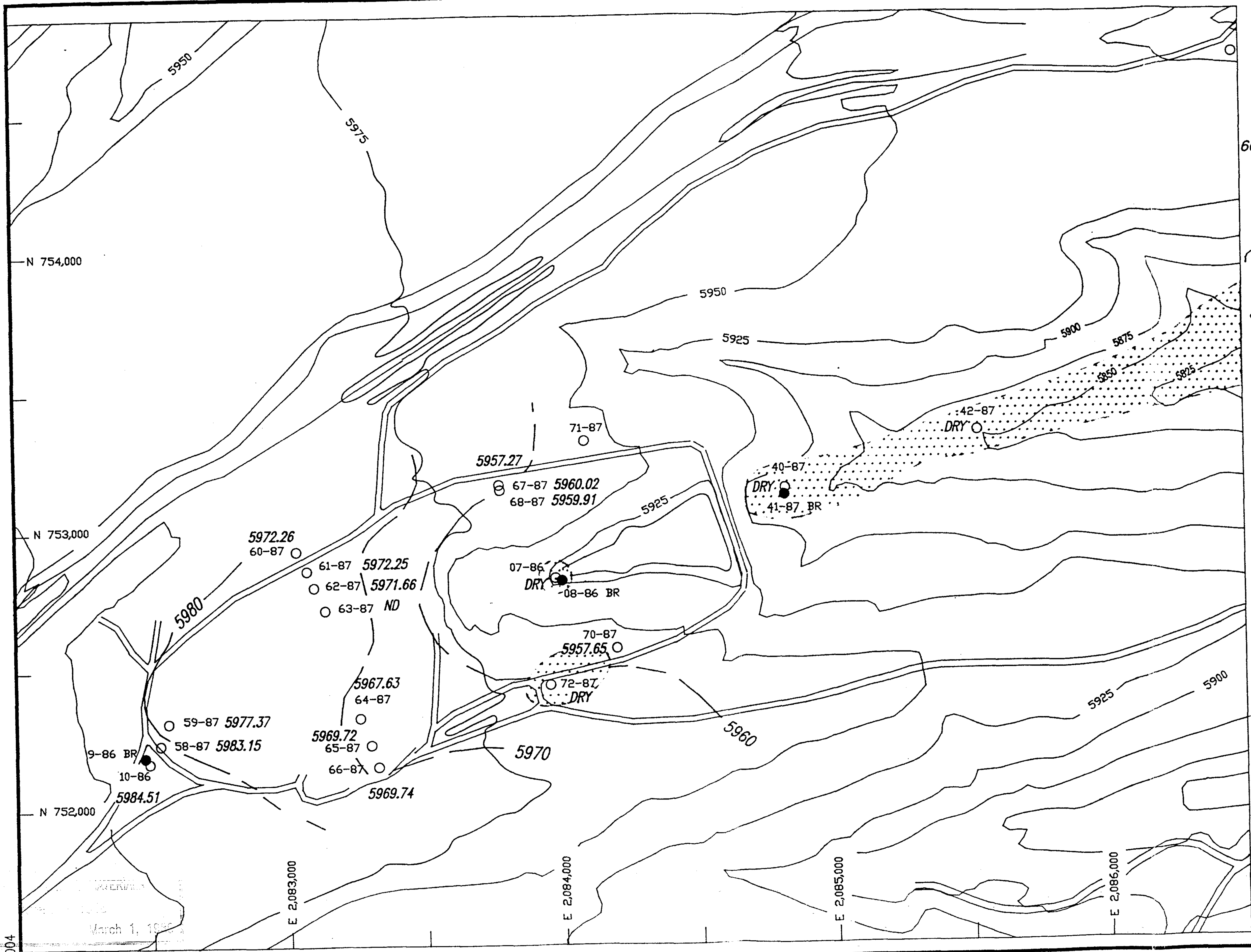
FIGURE 21

Present Landfill

TOTAL DISSOLVED SOLIDS CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER
First Quarter 1988

March 1, 1989

LF005



EXPLANATION

Alluvial Monitoring Well

Bedrock Monitoring Well

45-86 Well Designation

6028.62 Potentiometric Surface Elevation (feet above mean sea level)

6000 Line of Equal Potentiometric Surface Elevation (feet above mean sea level – dashed where approximately located)

Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendices E-4 and E-5 for Water Level Data

-N-

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 20

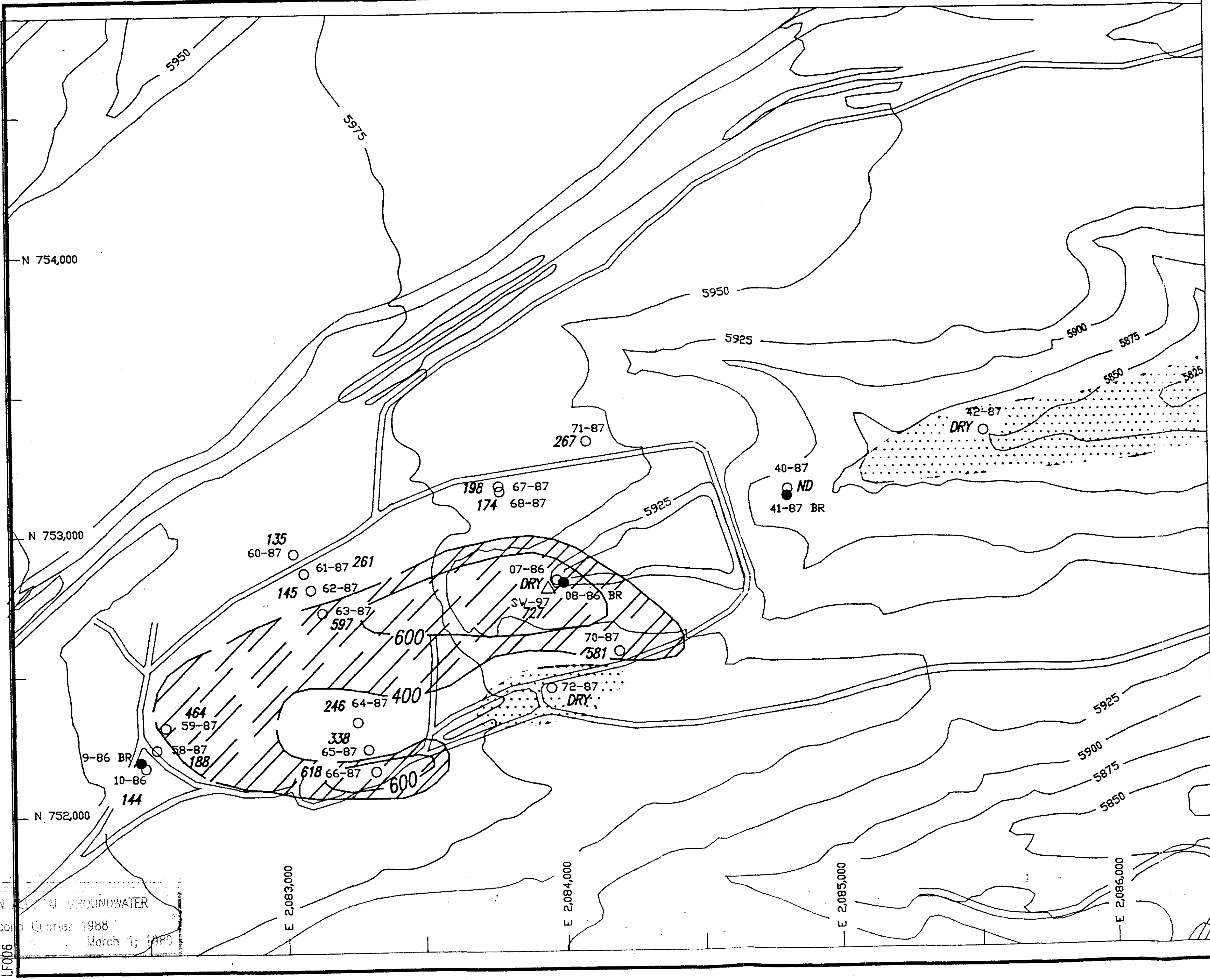
Present Landfill

WATER TABLE ELEVATION WITHIN SURFICIAL MATERIALS

November 1988

March 1, 1989

LF004



EXPLANATION

- ○ Alluvial Monitoring Well
- ● Bedrock Monitoring Well
- 45-86 Well Designation
- △ Surface Water Station
- **ND** No Data – Insufficient Sample for Inorganic Analyses
- ***174*** Total Dissolved Solids Concentration (mg/l)
- 400 Line of Equal Total Dissolved Solids Concentration (mg/l) – dashed where approximately located – contour interval varies
- Approximate Area of Unsaturated Surficial Materials
- Approximate Area of Groundwater Exceeding Proposed Concentration Limit (400 mg/l)

NOTE: See Appendix D for Analytical Data

N

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

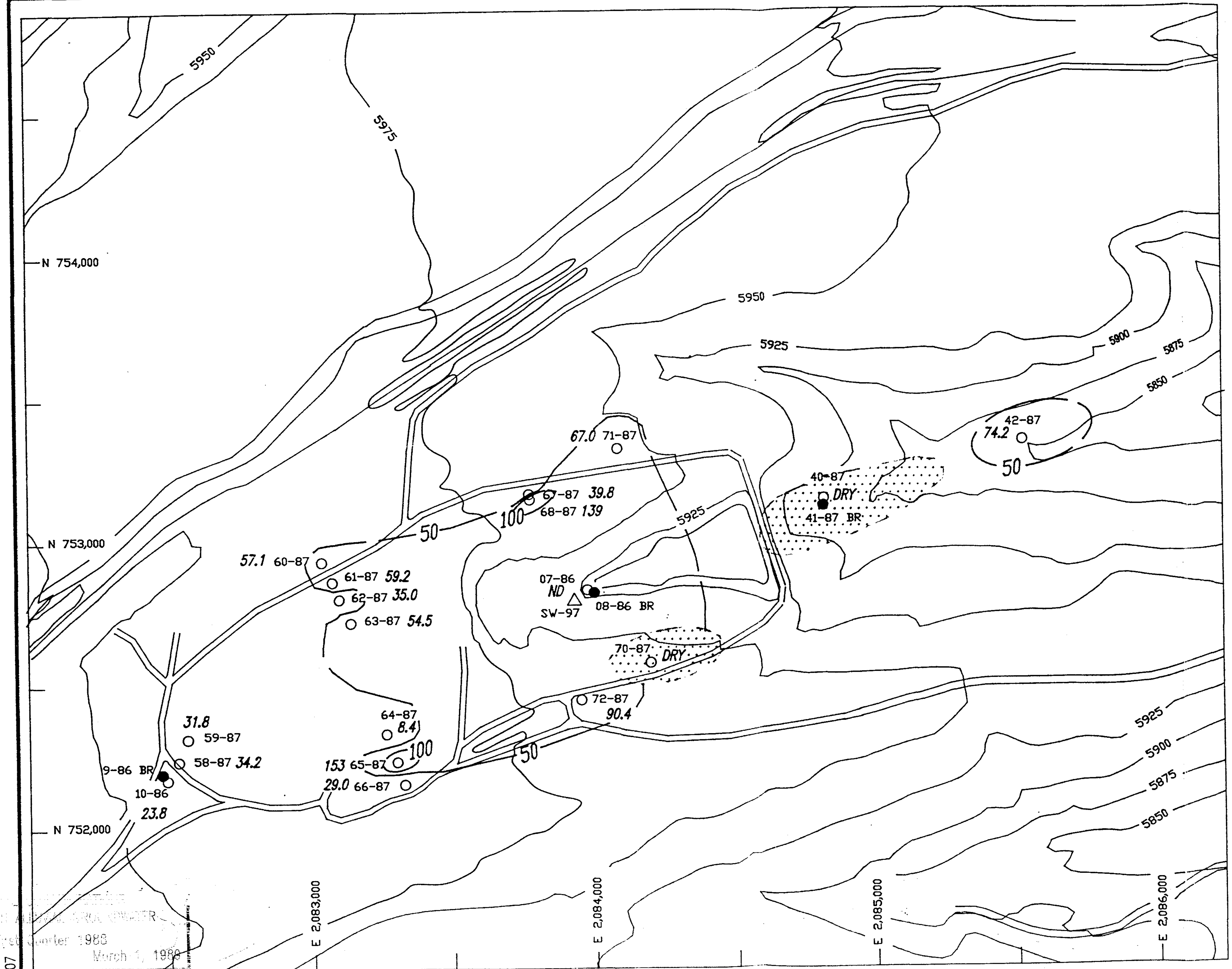
FIGURE 22

Present Landfill

TOTAL DISSOLVED SOLIDS CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER

Second Quarter 1988

March 1, 1989



EXPLANATION

- ○ Alluvial Monitoring Well
- ● Bedrock Monitoring Well
- 45-86 Well Designation
- △ Surface Water Station
- ND No Data – Insufficient Sample for Inorganic Analyses
- 139 Sulfate (mg/l) Concentration
- 400 Line of Equal Sulfate Concentration – dashed where approximately located – contour interval varies
- Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendix D for Analytical Data

N

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

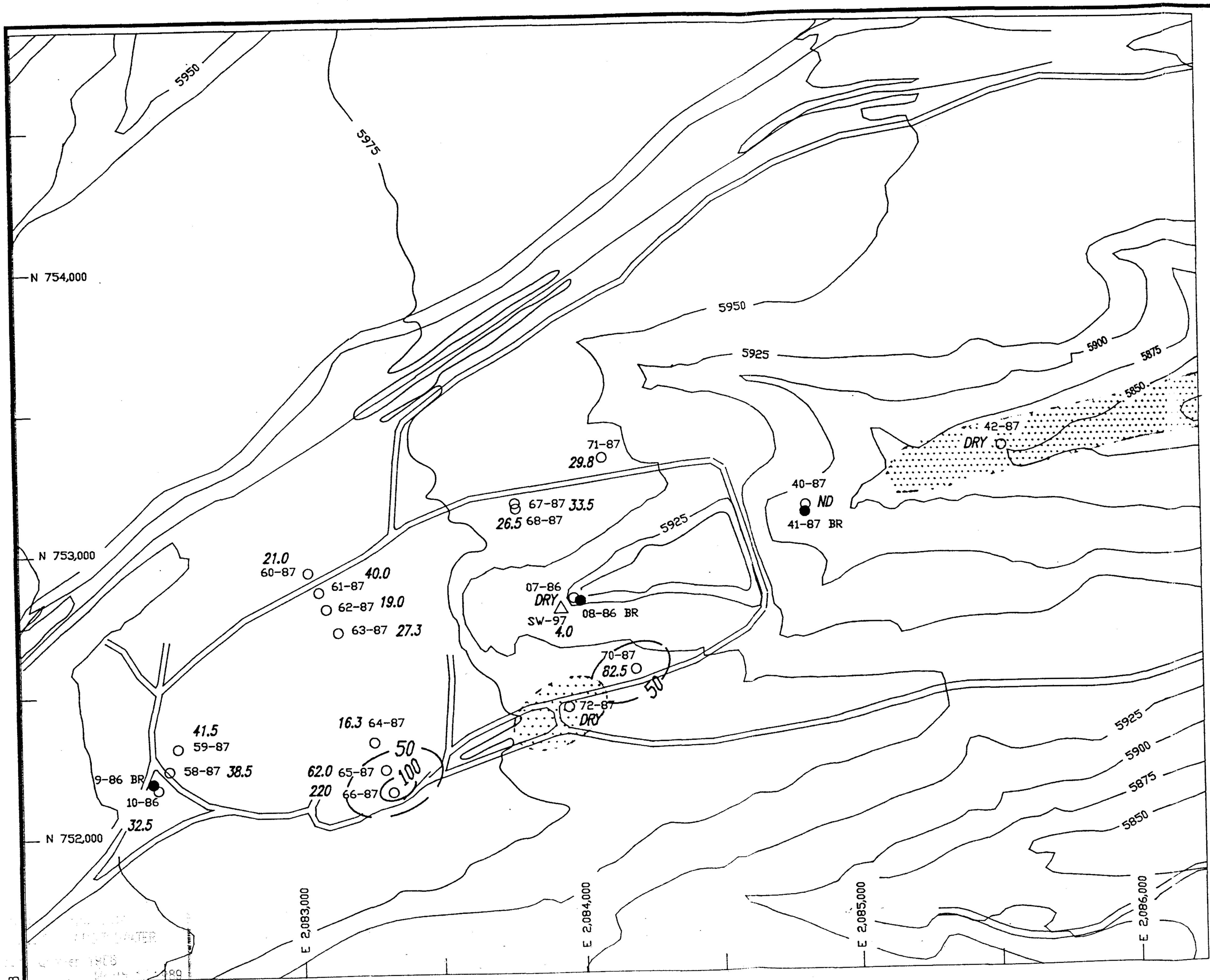
FIGURE 23

Present Landfill

SULFATE CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER
First Quarter 1988

March 1, 1989

LF007



EXPLANATION

○ Alluvial Monitoring Well

● Bedrock Monitoring Well

45-86 Well Designation

△ Surface Water Station

ND No Data – Insufficient Sample for Inorganic Analyses

139 Sulfate (mg/l) Concentration

400 Line of Equal Sulfate Concentration – dashed where approximately located – contour interval varies

Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendix D for Analytical Data

-N-

Scale: 1" = 350'

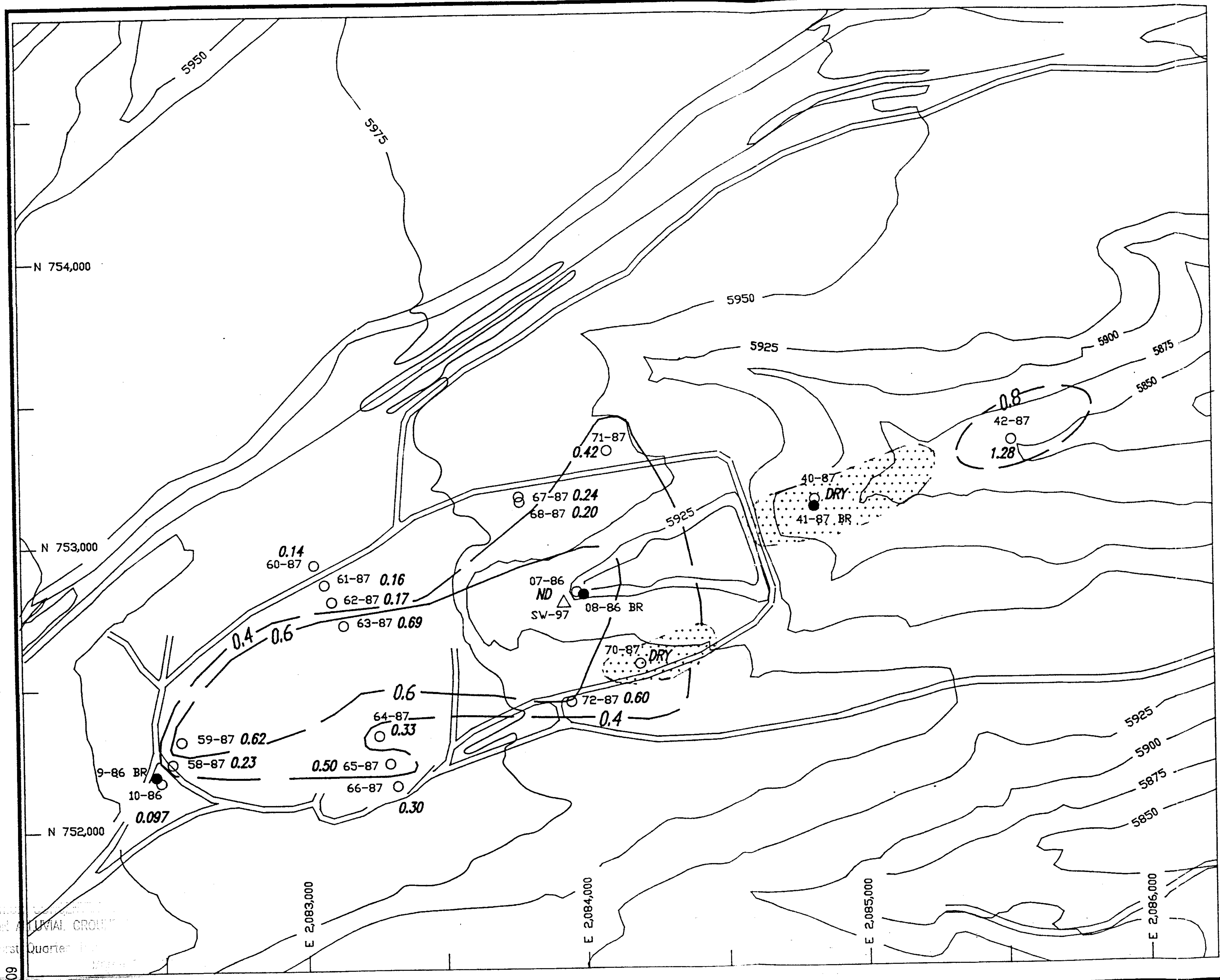
ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 24

Present Landfill

SULFATE CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER
Second Quarter 1988
March 1, 1989

LF008



EXPLANATION

○ Alluvial Monitoring Well

● Bedrock Monitoring Well

45-86 Well Designation

△ Surface Water Station

ND No Data – Insufficient Sample for Metals Analyses

0.24 Strontium Concentration (mg/l)

400 Line of Equal Strontium Concentration (mg/l) – dashed where approximately located – contour interval varies

Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendix D for Analytical Data

-N-

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

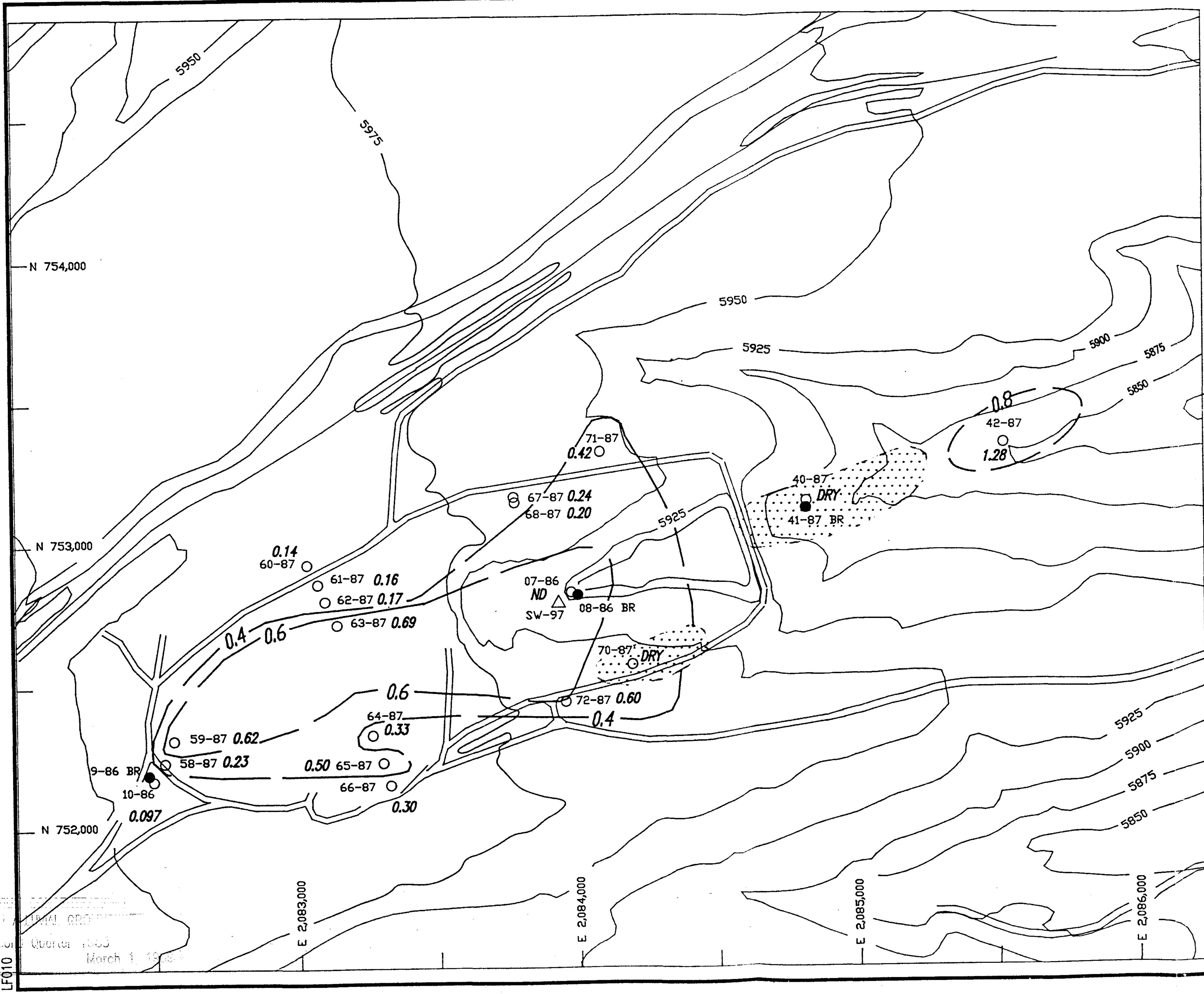
FIGURE 25

Present Landfill

STRONTIUM CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER
First Quarter 1988

March 1, 1989

LF009



EXPLANATION

- ○ Alluvial Monitoring Well
- ● Bedrock Monitoring Well
- 45-86 Well Designation
- △ Surface Water Station
- ND No Data – Insufficient Sample for Metals Analyses
- 0.24 Strontium Concentration (mg/l)
- 400 Line of Equal Strontium Concentration (mg/l) – dashed where approximately located – contour interval varies
- Approximate Area of Unsaturated Surficial Materials

NOTE: See Appendix D for Analytical Data

N

Scale: 1" = 350'

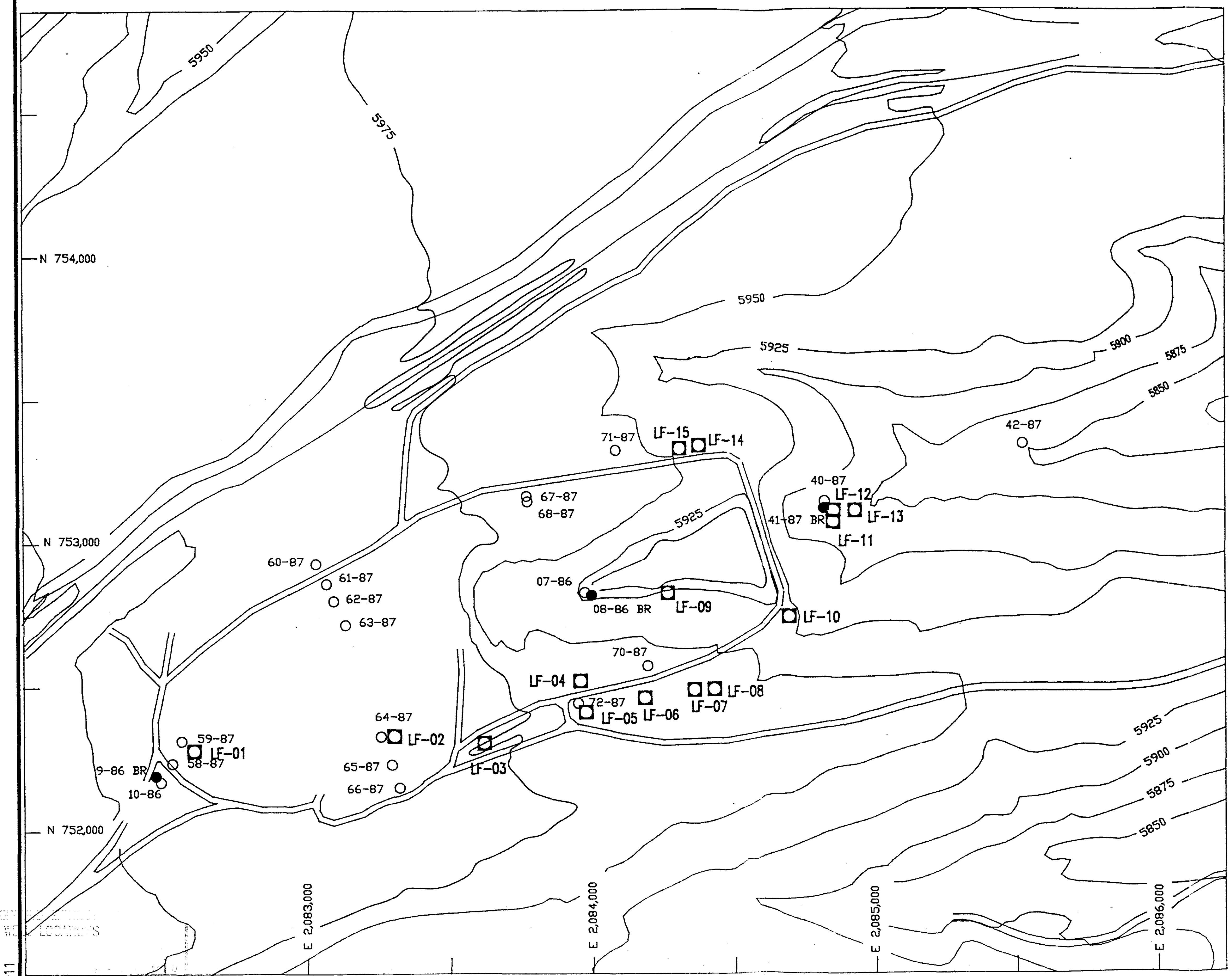
ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

FIGURE 26

Present Landfill

STRONTIUM CONCENTRATIONS (mg/l) IN ALLUVIAL GROUNDWATER
Second Quarter 1988
March 1, 1989

LF010



EXPLANATION

- ○ Alluvial Monitoring Well
- ● Bedrock Monitoring Well
- 45-86 Well Designation
- LF-5 ▢ Approximate Location of Proposed Monitoring Well

NOTE: See Table 35 for Well Descriptions

Scale: 1" = 350'

ROCKWELL INTERNATIONAL
Rocky Flats Plant
Golden, Colorado

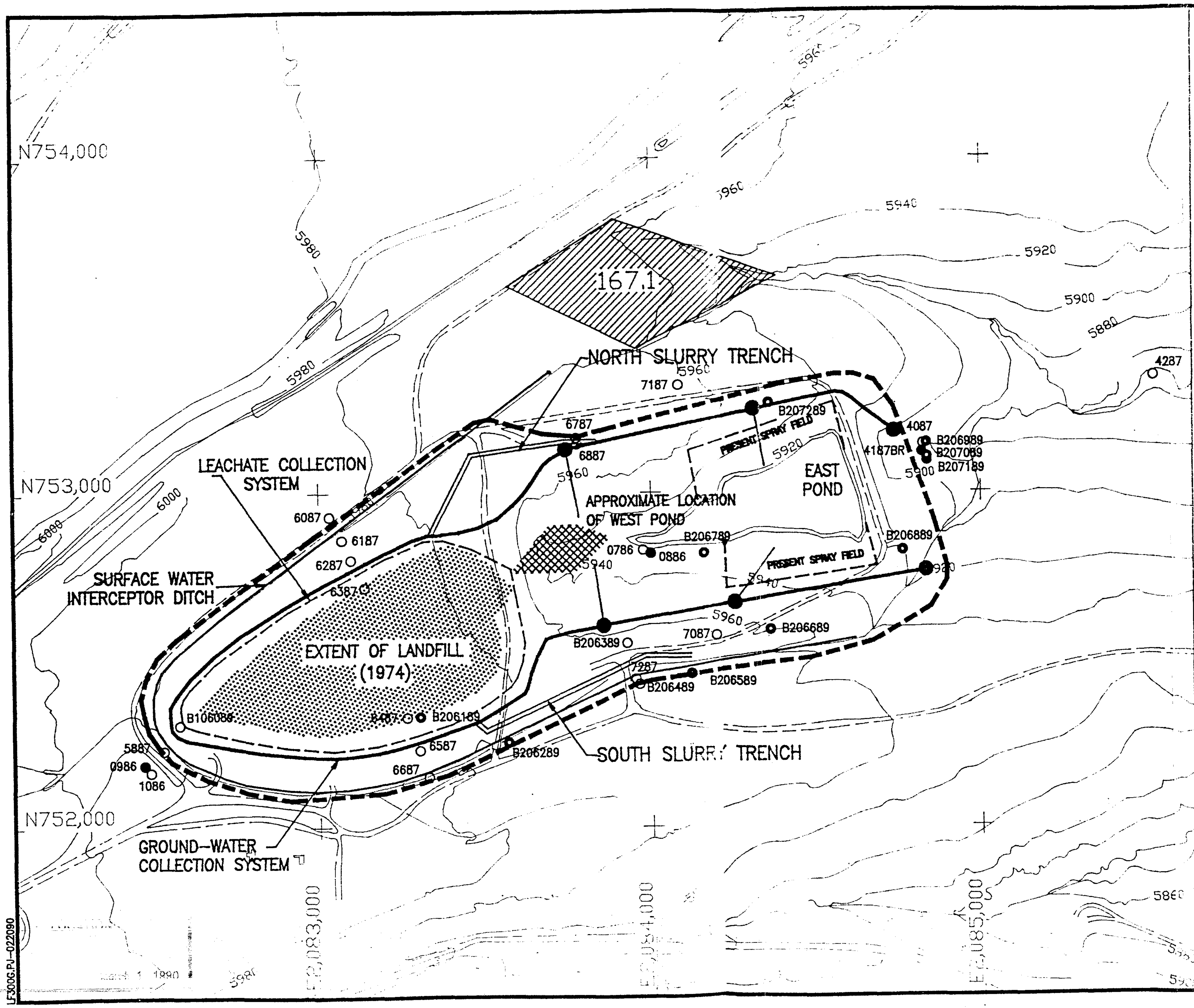
FIGURE 27

Present Landfill

PROPOSED MONITORING
WELL LOCATIONS

March 1, 1989

LF011



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

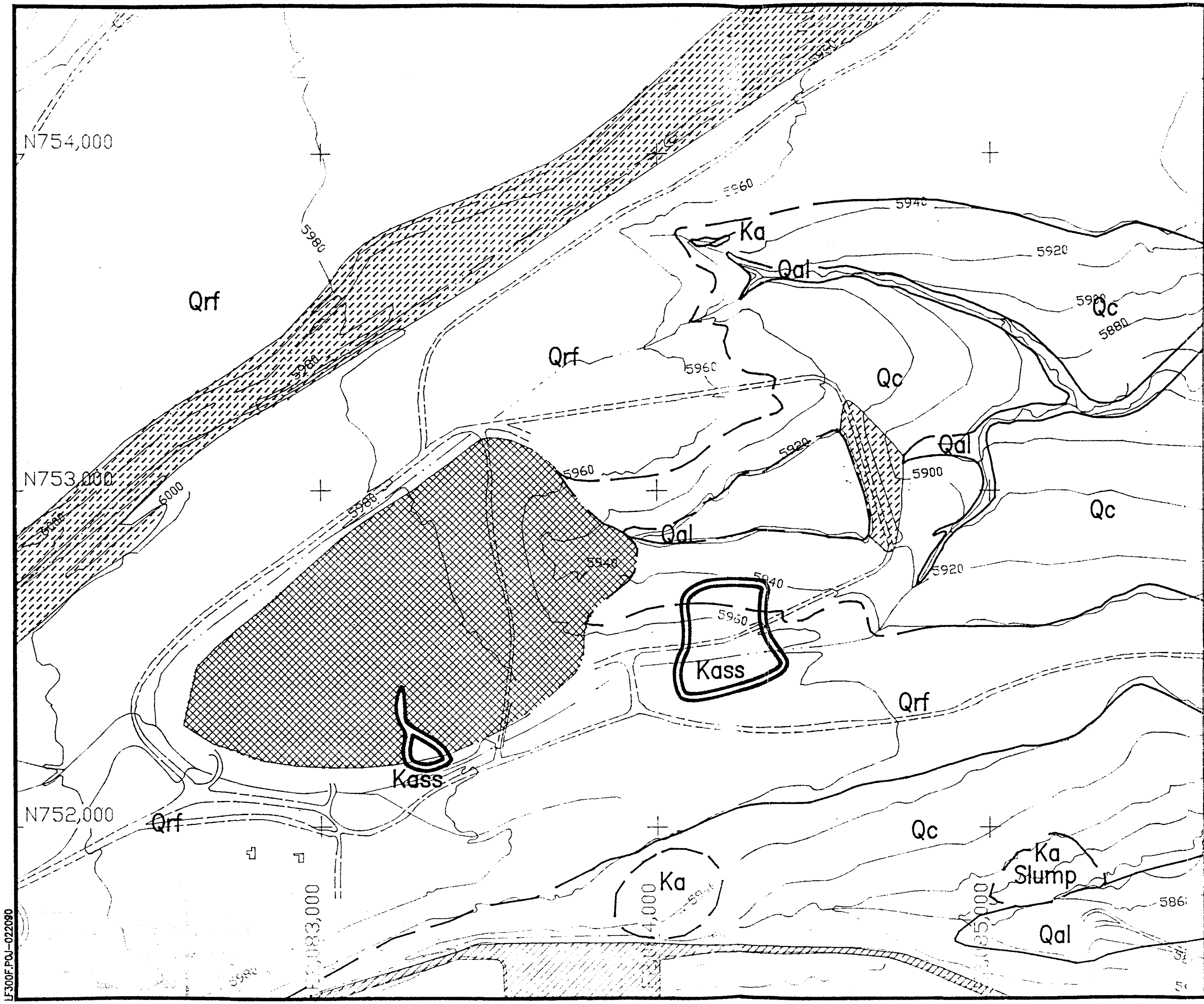
PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-1

WASTE MANAGEMENT AREA AND MONITORING WELL LOCATIONS

March 1, 1990

LF300G.PJ-022090



EXPLANATION

- Artificial Fill
- Pavement or Gravel
- Disturbed Ground

QUATERNARY

- Qal — Recent Valley Fill Alluvium
- Qc — Colluvium
- Qrf — Rocky Flats Alluvium

CRETACEOUS

- Ka — Arapahoe Formation, Claystone
- Kass — Arapahoe Formation, Sandstone
- Geologic Contact, dashed where approximately located
- Subcropping Sandstone (Kass) estimated extent

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

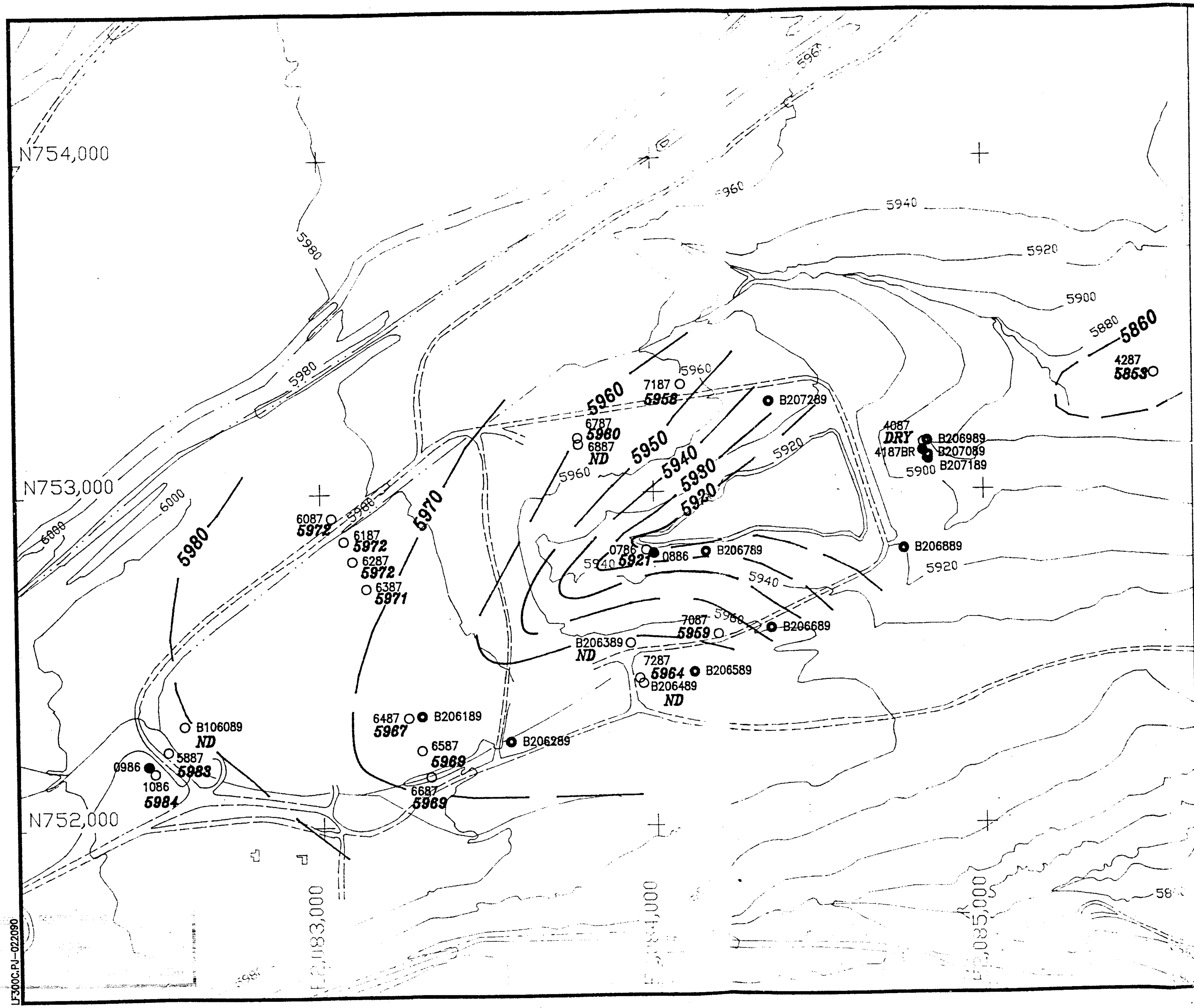
PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-2

GEOLOGIC MAP

March 1, 1990

LF300F.P0J-022090



EXPLANATION

B301889 ○ Alluvial Monitoring Well

B206889 ⊙ Weathered Bedrock Monitoring Well

B207189 ● Unweathered Bedrock Monitoring Well

5960 Potentiometric Surface Elevation February 1989 (feet above mean sea level)

5920 Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet

ND No Data

Unsaturated Surficial Materials – estimated extent

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

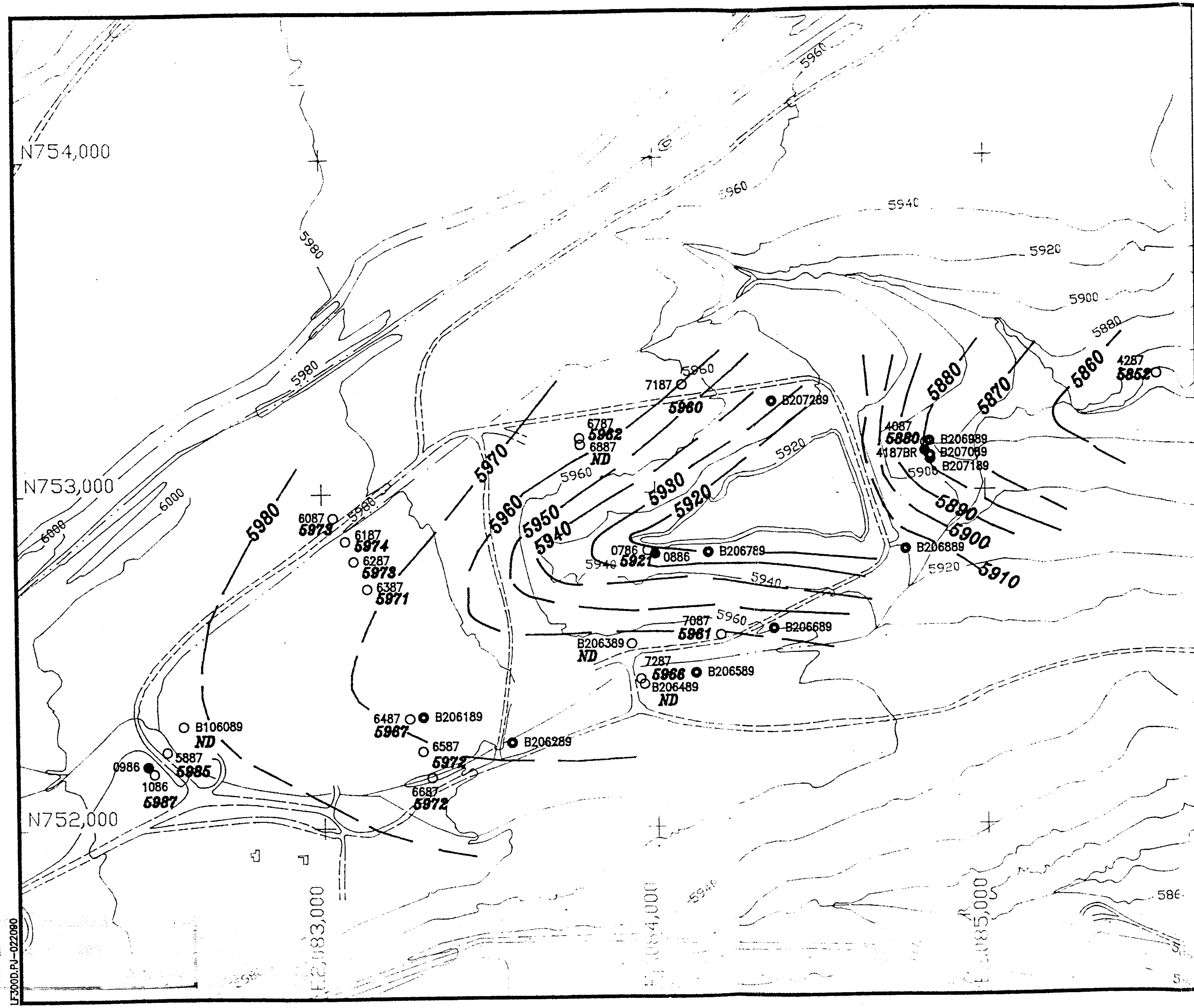
PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-3

POTENTIOMETRIC SURFACE
IN SURFICIAL MATERIALS

First Quarter 1989

March 1, 1990



EXPLANATION

B301889 ○ Alluvial Monitoring Well

B206889 ◉ Weathered Bedrock Monitoring Well

B207189 ● Unweathered Bedrock Monitoring Well

5960 Potentiometric Surface Elevation May 1989 (feet above mean sea level)

5920 Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval — 10 feet

ND No Data

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

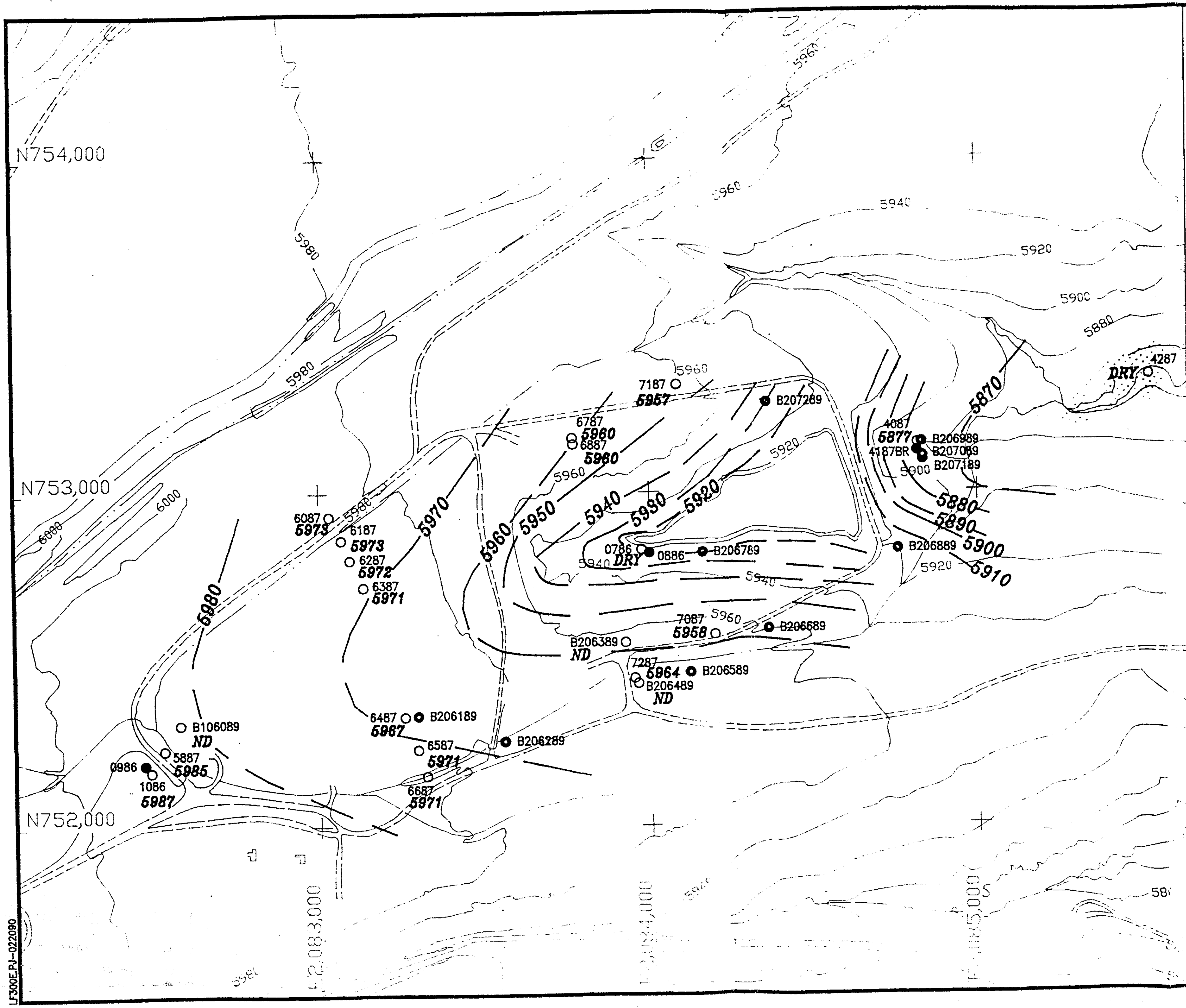
PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-4

POTENTIOMETRIC SURFACE
IN SURFICIAL MATERIALS

Second Quarter 1989

March 1, 1990



EXPLANATION

B206389 ○ Alluvial Monitoring Well

B206889 ⊙ Weathered Bedrock Monitoring Well

B207189 ● Unweathered Bedrock Monitoring Well

5960 Potentiometric Surface Elevation August 1989 (feet above mean sea level)

5957 Potentiometric Surface Elevation September 1989 (feet above mean sea level)

5920 Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet

ND No Data

Unsaturated Surficial Materials – estimated extent

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

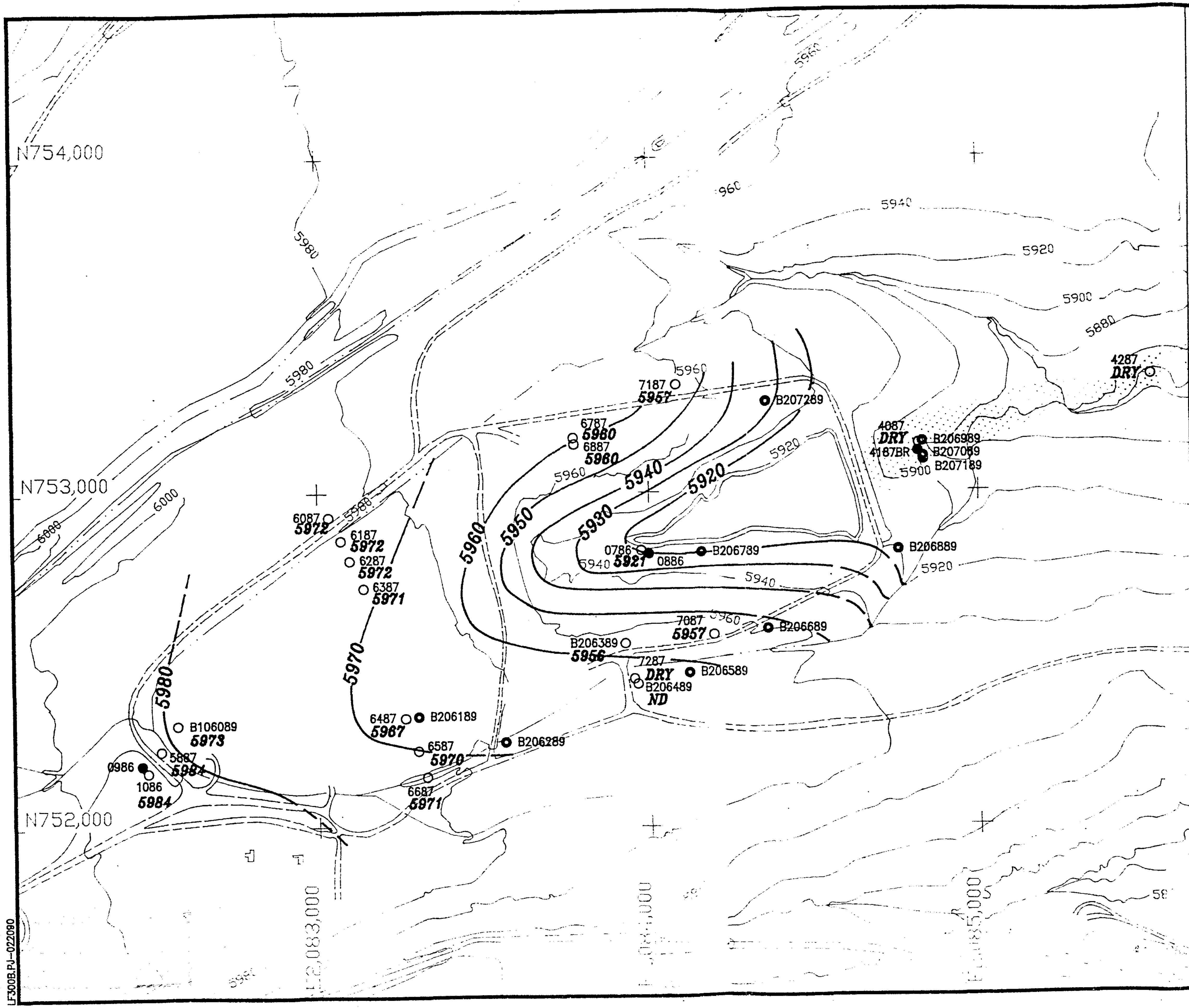
PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-5

POTENTIOMETRIC SURFACE
IN SURFICIAL MATERIALS

Third Quarter 1989

March 1, 1990



EXPLANATION

B301889 ○ Alluvial Monitoring Well

B206889 ⊙ Weathered Bedrock Monitoring Well

B207189 ● Bedrock Monitoring Well

5960 Potentiometric Surface Elevation November 1989 (feet above mean sea level)

5972 Potentiometric Surface Elevation October 1989 (feet above mean sea level)

5921 Potentiometric Surface Elevation December 1989 (feet above mean sea level)

5920 Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet

ND No Data

Unsaturated Surficial Materials estimated extent

N

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

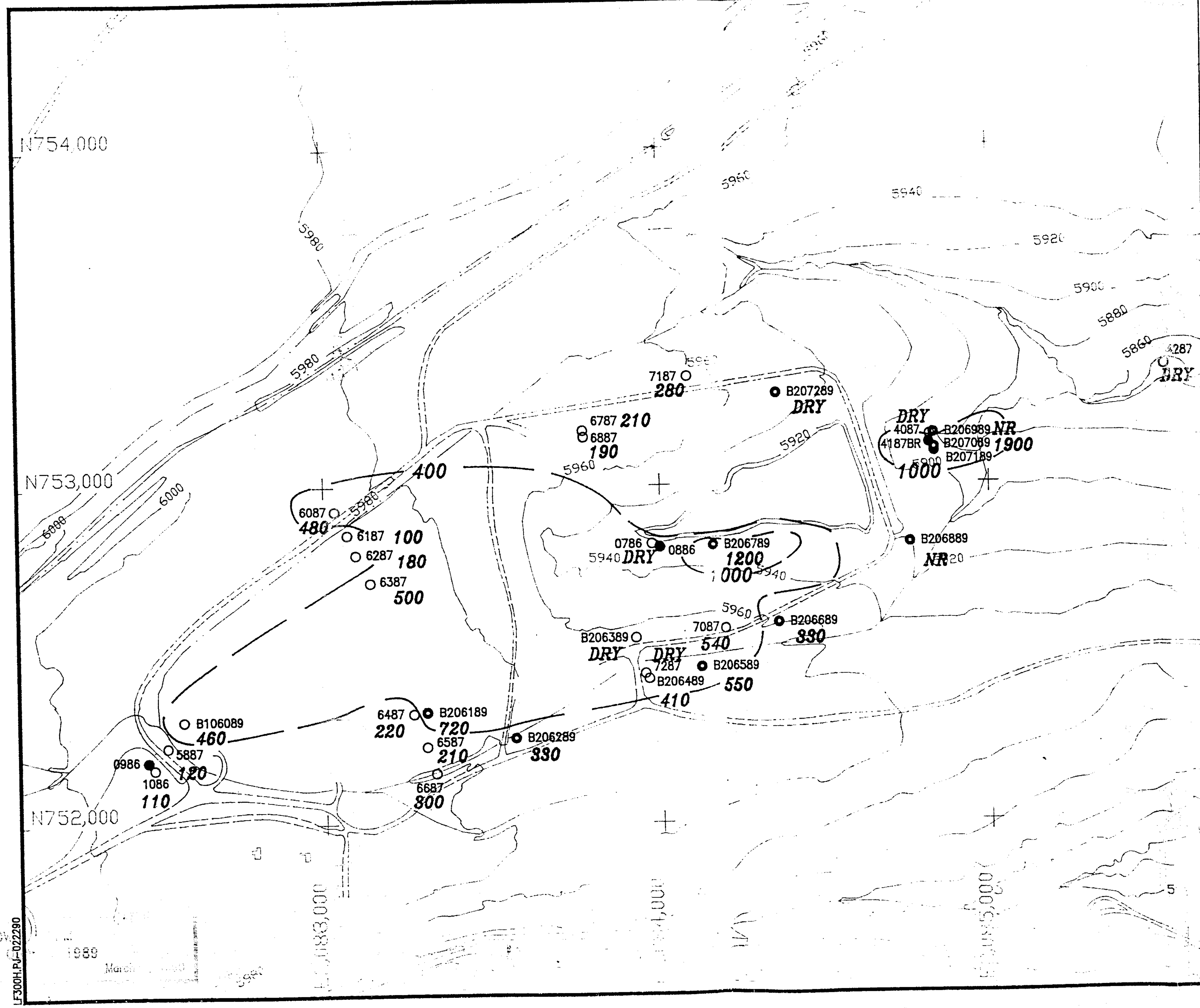
FIGURE 4-6

POTENTIOMETRIC SURFACE
IN SURFICIAL MATERIALS

Fourth Quarter 1989

March 1, 1990

LF300B.PJ-022090



EXPLANATION

B206389 ○ Alluvial Monitoring Well

B206889 ⊙ Weathered Bedrock Monitoring Well

B207189 ● Unweathered Bedrock Monitoring Well

220 TDS Concentration in Alluvial Ground Water (mg/l)

330 TDS Concentration in Weathered Bedrock Ground Water (mg/l)

400 Line of Equal TDS Concentration (mg/l). Dashed where approximately located Contour interval varies

DRY Insufficient Water for Metals analysis

NR Data not yet received

Scale: 1" = 300'

0' 150' 300'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

PRESENT LANDFILL AREA
1989 RCRA GROUND-WATER
MONITORING REPORT

FIGURE 4-7

TOTAL DISSOLVED SOLIDS CONCENTRATIONS
IN THE UNCONFINED GROUND-WATER
FLOW SYSTEM
Fourth Quarter 1989

March 1, 1990